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(21) Application number : 2000-368339 (71) Applicant : MINOLTA CO LTD

(22) Date of filing : 04.12.2000 (72) Inventor : HAGIMORI HITOSHI  
KONO TETSUO  
ISONO MASAFUMI

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(54) IMAGE PICKUP LENS DEVICE

(57) Abstract:

PROBLEM TO BE SOLVED: To provide an image pickup lens device, having a high variable power zoom lens system which has variable power ratio of about 7·10 and F-number of about 2.5·4, has excellent performance capable of being used as an optical system for a newest imaging device whose picture element pitch is small and has

excellent compactness property.

SOLUTION: This zoom lens system comprises a first lens group (Gr1) of positive power, a second lens group (Gr2) of negative power, a third lens group (Gr3) of positive power and a fourth lens group (Gr4) of negative power in this order from an object side, and the conditional expression  $1.1 < f_1/f_T < 2.5$ , where  $f_1$  is the focal distance of the first lens group (Gr1) and  $f_T$  is the focal distance of the entire system at a telephoto end (T) is satisfied.

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3.In the drawings, any words are not translated.

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## CLAIMS

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### [Claim(s)]

[Claim 1] The zoom lens system which performs variable power by consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation \*\*\*\*\* lens equipment and said zoom lens system has forward power in order [ side / body ], Image pick-up lens equipment characterized by satisfying the following conditional expression

(1) including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has negative power;

$1.1 < f_1/f_T < 2.5$  -- the focal distance of the (1), however  $f_1$ :1st lens group, and the focal distance of the whole system in  $f_T$ :tele edge -- it comes out.

[Claim 2] Image pick-up lens equipment according to claim 1 characterized by performing focusing and satisfying the following conditional expression (2) further when said 4th lens group moves in the direction of an optical axis;

$0.3 < |f_4/f_T| < 2$  -- (2), however the focal distance of the f4:4th lens group -- it comes out.

[Claim 3] Image pick-up lens equipment according to claim 1 or 2 with which said 1st lens group moves and spacing of said 3rd lens group and said 4th lens group is characterized by for a wide angle edge to a middle focal distance increasing, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge.

[Claim 4] The zoom lens system which performs variable power by consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation \*\*\*\*\* lens equipment and said zoom lens system has forward power in order [ side / body ], Image pick-up lens equipment characterized by for the 1st lens group moving in zooming and satisfying the following conditional expression (3) including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has negative power;

$0.3 < D_{34} W/D_{34T} < 2.5$  -- (3) however air spacing between the 3rd lens groups and the 4th lens groups in a D34W:wide angle edge, and air spacing

between the 3rd lens groups and the 4th lens groups in a D34T:tele edge -- it comes out.

[Claim 5] Image pick-up lens equipment according to claim 4 characterized by said 4th lens group moving to a body side in zooming from a wide angle edge to a tele edge.

[Claim 6] Image pick-up lens equipment according to claim 4 or 5 with which spacing of said 3rd lens group and said 4th lens group is characterized by for a wide angle edge to a middle focal distance increasing, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge.

[Claim 7] Image pick-up lens equipment according to claim 4, 5, or 6 characterized by for focusing being performed by migration of said 4th lens group, and satisfying the following conditional expression (4) further;  $0.5 < \beta_{W4} < 2$  -- the lateral magnification of the 4th lens group in a (4), however  $\beta_{W4}$ :wide angle edge -- it comes out.

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[Translation done.]

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## DETAILED DESCRIPTION

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[Detailed Description of the Invention]

[0001]

[Field of the Invention] the image pick-up lens equipment to which this invention is optically incorporated according to optical system, and outputs especially the image of a photographic subject as an electric signal with an image sensor about image pick-up lens equipment -- {-- for example, it is related with the image pick-up lens equipment which equipped a digital camera; video camera; digital video unit, the personal computer, the mobile computer, the cellular phone, the information personal digital assistant (PDA:Personal Digital Assistant), etc. with built-in or main component} of the camera by which external is carried out, and the zoom lens system of high variable power compact especially.

[0002]

[Description of the Prior Art] the 1st lens group which has forward power in order [ side / body ] as a high variable power zoom lens for digital cameras, the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has forward power -- since -- the type which changes occupies the mainstream conventionally (for example, JP,4-296809,A). This is because forward, negative, forward, and a forward type are excellent in compactability.

[0003] moreover, as a zoom lens which attained the high variable power ratio The 1st lens group which has forward power in order [ side / body ], and the 2nd lens group which has negative power, The 3rd lens group which has forward power, and the 4th lens group which has negative power, since -- with the 1st lens group which has forward power in order [ side / the what (for example, JP,5-341189,A) side changes, and / body ] the 2nd lens group which has negative power, the 3rd lens group which has forward power, the 4th lens group which has negative power, and the 5th lens group which has forward power -- since -- what changes (for example, JP,10-111457,A) is known.

[0004]

[Problem(s) to be Solved by the Invention] Since the 1st lens group is immobilization in zooming, the zoom lens of forward, negative, forward, and the negative type proposed by JP,5-341189,A is unsuitable for further high-performance-izing accompanying the further formation of a high variable power ratio and the further formation of a small pitch of an image sensor. Moreover, although the zoom lens of forward, negative, forward, negative, and the forward type proposed by JP,10-111457,A also moves the 1st lens group in zooming, especially many aberration generated by each group since the power of the 1st and 2nd lens group is strong becomes large. Therefore, it is difficult to realize further high performance-ization accompanying the further formation of a high variable power ratio and the further formation of a small pitch of an image sensor. Moreover, the type containing forward, negative, forward, and the negative one to which the 4th lens group changes from a negative group also has the fault that it is a little inferior by compactability compared with forward and a negative, forward, and forward type.

[0005] This invention is made in view of such a situation. The purpose It is in realizing a type with the performance which exceeds forward, negative, forward, and a forward type by compactability. 7 times to about 10 times and the f number

especially about by 2.5 to four [ a variable power ratio ] It aims at offering the image pick-up lens equipment which has the high variable power zoom lens system which had the high engine performance which can be used also as optical system for the image sensors of the latest small pixel pitch, and was excellent in compactability.

[0006]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, the image pick-up lens equipment of the 1st invention The zoom lens system which performs variable power by consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation \*\*\*\*\* lens equipment and said zoom lens system has forward power in order [ side / body ], It is characterized by satisfying the following conditional expression (1) including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th lens group which has negative power.

$1.1 < f_1/f_T < 2.5$  -- the focal distance of the (1), however  $f_1$ :1st lens group, and the focal distance of the whole system in  $f_T$ :tele edge -- it comes out.

[0007] In the configuration of invention of the above 1st, focusing is performed and the image pick-up lens equipment of the 2nd invention is characterized by satisfying the following conditional expression (2) further, when said 4th lens group moves in the direction of an optical axis.

$0.3 < |f_4/f_T| < 2$  -- (2), however the focal distance of the f4:4th lens group -- it comes out.

[0008] The image pick-up lens equipment of the 3rd invention is characterized by for said 1st lens group moving, for spacing of said 3rd lens group and said 4th lens group increasing from a wide angle edge to a middle focal distance, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge in the configuration of the above 1st or the 2nd invention.

[0009] The zoom lens system which performs variable power by the image pick-up lens equipment of the 4th invention consisting of two or more lens groups, and changing lens group spacing, The image sensor which changes into an electric signal the optical image formed of the zoom lens system, The 1st lens group in which it is preparation \*\*\*\*\* lens equipment and said zoom lens system has forward power in order [ side / body ], Including the 2nd lens group which has negative power, the 3rd lens group which has forward power, and the 4th

lens group which has negative power, the 1st lens group moves in zooming and it is characterized by satisfying the following conditional expression (3).

0.3 -- < -- D34 W/D34T<2.5 -- (3) however air spacing between the 3rd lens groups and the 4th lens groups in a D34W:wide angle edge, and air spacing between the 3rd lens groups and the 4th lens groups in a D34T:tele edge -- it comes out.

[0010] The image pick-up lens equipment of the 5th invention is characterized by said 4th lens group moving to a body side in zooming from a wide angle edge to a tele edge in the configuration of invention of the above 4th.

[0011] The image pick-up lens equipment of the 6th invention is characterized by for spacing of said 3rd lens group and said 4th lens group increasing from a wide angle edge to a middle focal distance, and a middle focal distance to a tele edge decreasing in zooming from a wide angle edge to a tele edge in the configuration of the above 4th or the 5th invention.

[0012] In the configuration of the above 4th, the 5th, or the 6th invention, focusing is performed by migration of said 4th lens group, and the image pick-up lens equipment of the 7th invention is characterized by satisfying the following conditional expression (4) further.

$0.5 < \beta_4 < 2$  -- the lateral magnification of the 4th lens group in a (4), however  
 $\beta_4:wide$  angle edge -- it comes out.

[0013]

[Embodiment of the Invention] Hereafter, the image pick-up lens equipment which carried out this invention is explained, referring to a drawing. the camera with which the image pick-up lens equipment which incorporates the image of a photographic subject optically and is outputted as an electric signal is used for still picture photography and animation photography of a photographic subject -- {-- for example, it is the main component of built-in or camera} by which external is carried out at a digital camera; video camera; digital video unit, a personal computer, a mobile computer, a cellular phone, an information personal digital assistant (PDA), etc. as shown in drawing 26, the image pick-up lens equipment comes out sequentially from a body (photographic subject) side with the image sensor (SR) which changes into an electric signal the optical image formed of the taking-lens system (TL) which forms an objective optical image, and the plane-parallel plate (PL) equivalent to an optical low pass filter etc. and a taking-lens system (TL), and is constituted.

[0014] With the gestalt of each operation mentioned later, the zoom lens system

which consists of two or more lens groups is used as a taking-lens system (TL), two or more lens groups move in accordance with an optical axis (AX), and variable power is performed by changing lens group spacing. Solid state image sensors which consist, for example of two or more pixels as an image sensor (SR), such as CCD (Charge Coupled Device) and a CMOS (Complementary Metal Oxide Semiconductor) sensor, are used, and the optical image formed of the zoom lens system is changed into an electric signal. Moreover, when the optical image which should be formed by the zoom lens system passes the optical low pass filter (PL) which has the predetermined cut-off frequency property determined with the pixel pitch of an image sensor (SR), spatial frequency characteristics are adjusted so that the so-called clinch noise generated in case it is changed into an electric signal may be minimized. Predetermined digital image processing, picture compression processing, etc. are performed if needed, it is recorded on memory (semiconductor memory, optical disk, etc.) as a digital video signal, a cable is minded depending on the case, or the signal generated with the image sensor (SR) is changed into an infrared signal, and is transmitted to other devices.

[0015] Drawing 1 - drawing 9 are the lens block diagrams corresponding to the

zoom lens system which constitutes the gestalt of the 1st - the 9th operation, respectively, and show lens arrangement in a wide angle edge (W) in the optical cross section. The arrow head  $m_j$  ( $j = 1, 2, \dots$ ) in each lens block diagram shows typically migration (however, the broken-line arrow head  $m_j$  expresses that it is location immobilization in zooming.) of the  $j$ -th lens group ( $Gr_j$ ) in zooming from a wide angle edge (W) to a tele edge (T), respectively, and the arrow head  $m_F$  shows the migration direction of the focal group in focusing to the contiguity from infinite distance. Moreover, among each lens block diagram, the field where  $r_i$  ( $i = 1, 2$  and  $3, \dots$ ) was attached is counted from a body (photographic subject) side, and is the  $i$ -th field, and the field where \* mark was given to  $r_i$  is the aspheric surface. Axial top-face spacing to which  $d_i$  ( $i = 1, 2$  and  $3, \dots$ ) was given is variable spacing which counts from a body side and changes in zooming among the  $i$ -th axial top-face spacing.

[0016] Each zoom lens system of the gestalt of each operation contains the 1st lens group ( $Gr_1$ ) which has forward power, the 2nd lens group ( $Gr_2$ ) which has negative power, the 3rd lens group ( $Gr_3$ ) which has forward power, and the 4th lens group ( $Gr_4$ ) which has negative power in order [ side / body ]. And the glass plane-parallel plate equivalent to an optical low pass filter etc., i.e., a glass plate,

(PL) is arranged at the image surface side as a zoom lens system used for the camera (for example, digital camera) equipped with the solid state image sensor (for example, CCD). Also in the gestalt of which operation, a glass plate (PL) is location immobilization in zooming, and the 3rd lens group (Gr3) is extracted to the maximum body side, and contains (ST).

[0017] the 1st lens group (Gr1) in which the zoom lens system of the gestalt of the 1st operation has forward power in order [ side / body ], the 2nd lens group (Gr2) which has negative power, the 3rd lens group (Gr3) which has forward power, and the 4th lens group (Gr4) which has negative power -- since -- it is 4 group zoom lens of forward, negative, forward, and the negative type which changes. The zoom lens system of the gestalt of the 2nd - the 4th, 6th, 8th, and 9th operation The 1st lens group (Gr1) which has forward power in order [ side / body ], and the 2nd lens group which has negative power (Gr2), the 3rd lens group (Gr3) which has forward power, the 4th lens group (Gr4) which has negative power, and the 5th lens group (Gr5) which has forward power -- since -- it is 5 group zoom lens of forward, negative, forward, negative, and the forward type which changes.

[0018] The 1st lens group in which the zoom lens system of the gestalt of the 5th

operation has forward power in order [ side / body ] (Gr1), The 2nd lens group (Gr2) which has negative power, and the 3rd lens group which has forward power (Gr3), the 4th lens group (Gr4) which has negative power, the 5th lens group (Gr5) which has forward power, and the 6th lens group (Gr6) which has negative power -- since -- it is 6 group zoom lens of forward, negative, forward, negative, forward, and the negative type which changes. The 1st lens group in which the zoom lens system of the gestalt of the 7th operation has forward power in order [ side / body ] (Gr1), The 2nd lens group (Gr2) which has negative power, and the 3rd lens group which has forward power (Gr3), the 4th lens group (Gr4) which has negative power, the 5th lens group (Gr5) which has forward power, and the 6th lens group (Gr6) which has forward power -- since -- it is 6 group zoom lens of forward, negative, forward, negative, forward, and the forward type which changes.

[0019] Any gestalt of operation is the zoom type which starts in forward, negative, forward, and a negative one. Compared with forward, negative, forward, and the forward type both whose 3rd and 4th lens groups (Gr3, Gr4) have forward power By the zoom type containing forward, negative, forward, and the negative one which made the 4th lens group (Gr4) the negative lens group Since the sign of

the power of the 3rd lens group (Gr3) and the 4th lens group (Gr4) is different, a higher variable power ratio can be earned by the 3rd and 4th lens group (Gr3, Gr4), and there is a merit of being easy to secure high variable power. in addition, as a type containing forward, negative, forward, and a negative one (Forward, negative, forward, and negative) 4 group type; (Forward, negative, forward, and negative) Variations, such as - forward (forward, negative, forward, and negative), negative 5 group type; (forward, negative, forward, and negative), forward [ negative ], and forward one, - (forward, negative, forward, and negative) forward and a negative one, a - (forward, negative, forward, and negative) negative, and 6 group type forward (forward, negative, forward, and negative), negative, and negative, are mentioned.

[0020] In the zoom lens system of the type which contains forward and a negative, forward, and negative zoom group in order, it is more desirable than a body side like the gestalt of each operation to satisfy the following conditional expression (1). Thereby, the compact zoom lens system of high variable power is realizable. And the high engine performance which a variable power ratio can use by 7 times to about 10 times, and the f number can use about by 2.5 to four also as optical system for the image sensors (SR) of the latest small pixel pitch

can be obtained.

$1.1 < f_1/f_T < 2.5$  -- the focal distance of the (1), however  $f_1$ :1st lens group (Gr1),  
and  $f_T$ : -- the focal distance of the whole system in a tele edge (T) -- it comes out.

[0021] If the minimum of conditional expression (1) is exceeded, the power of the  
1st lens group (Gr1) will become strong too much, and it will become difficult to  
remove the spherical aberration especially in a tele edge (T). Moreover, if the  
upper limit of conditional expression (1) is exceeded, the power of the 1st lens  
group (Gr1) will become weak too much, and it will become difficult to secure  
especially the compactability in a tele edge (T).

[0022] When the 4th lens group (Gr4) moves in the direction of an optical axis  
(AX) in the zoom lens system of the type which contains forward and a negative,  
forward, and negative zoom group in order from a body side like the gestalt of  
each operation, it is desirable for focusing to be performed and to satisfy the  
following conditional expression (2) further. The zoom lens system which  
secured the higher engine performance is realizable with this. Moreover, it is still  
more desirable to satisfy conditional expression (2) with said conditional  
expression (1).

$0.3 < |f_4/f_T| < 2$  -- (2), however the focal distance of the  $f_4$ :4th lens group (Gr4) -- it

comes out.

[0023] As shown in conditional expression (2), the power of the 4th lens group (Gr4) is comparatively weak, therefore lens number of sheets also has few 4th lens groups (Gr4). It is optimal that migration ( $mF$ ) of the direction of an optical axis (AX) of the 4th lens group with small lens weight (Gr4) performs focusing from this. However, when the system in which focusing in an image sensor (SR) is possible can be adopted, even if migration of an image sensor (SR) is made to perform focusing, it does not interfere.

[0024] If the minimum of conditional expression (2) is exceeded, the power of the 4th lens group (Gr4) will become strong too much, and it will become difficult to remove the performance degradation at the time of the contiguity especially in a tele edge (T). Moreover, if the upper limit of conditional expression (2) is exceeded, the power of the 4th lens group (Gr4) will become weak too much, the lens movement magnitude of the 4th lens group at the time of a focus (Gr4) will become large too much, and a result by which the compactability of the whole camera cone is spoiled will be brought.

[0025] Moreover, it sets like the gestalt of each operation to zooming from a wide angle edge (W) to a tele edge (T). It is desirable for the 1st lens group (Gr1) to

move, for spacing of the 3rd lens group (Gr3) and the 4th lens group (Gr4) to increase from a wide angle edge (W) to a middle focal distance, and for a middle focal distance to a tele edge (T) to decrease. The zoom lens system of high variable power is realizable with this. Moreover, it is still more desirable to satisfy conditional expression (1) and conditional expression (2) in this characteristic zoom configuration.

[0026] The type with which the 1st lens group (Gr1) is being fixed in zooming as optical system conventionally used for the video camera or the digital camera from the balance of the compactability searched for as the whole product and the difficulty of a camera cone configuration was in use. However, since it is in the situation that the further party KUTONESU and high variable power are called for, from now on, it is desirable to make the 1st lens group (Gr1) movable in zooming. Each beam-of-light height which carries out incidence to the 2nd lens group (Gr2) in a tele edge (T) can be made small, and it becomes easy to perform amendment of many aberration by moving the 1st lens group (Gr1) from a wide angle edge (W) to a body side in zooming to a tele edge (T). Moreover, in zooming from a wide angle edge (W) to a tele edge (T), when spacing of the 3rd and 4th lens group (Gr3, Gr4) considers as the configuration in which a wide

angle edge (W) to a middle focal distance increases, and a middle focal distance to a tele edge (T) decreases, it becomes possible to amend the curvature of field in a middle focal distance field good, and the zoom lens system of high variable power can be realized as a result.

[0027] Moreover, like the gestalt of each operation, it is desirable to arrange the aspheric surface in the 2nd lens group (Gr2), and the zoom lens system which starts in a wide angle more is obtained by establishing the aspheric surface at the 2nd lens group (Gr2). If the focal distance of a wide angle edge (W) tends to be made smaller and it is going to enlarge a photography field angle, distortion amendment in a wide angle edge (W) will become difficult especially. In order to remove this fault, it is desirable to arrange the aspheric surface in the comparatively high 2nd lens group (Gr2) of the beam-of-light height besides the shaft by the side of a wide angle, and it can amend distortion aberration good by this. Therefore, it is still more desirable to arrange the aspheric surface in the 2nd lens group (Gr2), while filling conditional expression (1) and conditional expression (2), when obtaining high optical-character ability, holding compactability.

[0028] If it is in the zoom lens system which the 1st lens group (Gr1) moves to

order in zooming including forward and a negative, forward, and negative zoom group from a body side like the gestalt of each operation, it is desirable to satisfy the following conditional expression (3). Thereby, the compact zoom lens system of high variable power is realizable. And the high engine performance which a variable power ratio can use by 7 times to about 10 times, and the f number can use about by 2.5 to four also as optical system for the image sensors (SR) of the latest small pixel pitch can be obtained.

0.3 -- < -- D34 W/D34T<2.5 -- (3) however air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a D34W:wide angle edge (W), and D34T: -- air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a tele edge (T) -- it comes out.

[0029] If the minimum of conditional expression (3) is exceeded, air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a tele edge (T) will become large too much, and it will become difficult to secure the compactability in a tele edge (T). Moreover, if the upper limit of conditional expression (3) is exceeded, air spacing between the 3rd lens groups (Gr3) and the 4th lens groups (Gr4) in a wide angle edge (W) will become large too much, and it will become difficult to secure the compactability in a wide angle edge (W).

[0030] It is desirable the 1st lens group (Gr1) not only to move, but for the 4th lens group (Gr4) to move to a body side in zooming from a wide angle edge (W) to a tele edge (T) in zooming, as mentioned above in the zoom lens system which contains forward and a negative, forward, and negative zoom group in order from the body side like the gestalt of each operation. By this, many variable power ratios in the 4th lens group (Gr4) can be earned, and a zoom lens system with a higher variable power ratio can be realized. Moreover, when balancing compactability, it is still more desirable to make it fill conditional expression (3).

[0031] Moreover, it sets in the zoom lens system which contains forward and a negative, forward, and negative zoom group in order [ side / body ] like the gestalt of each operation. As mentioned above, it sets to zooming from a wide angle edge (W) to a tele edge (T). Although it is desirable for spacing of the 3rd lens group (Gr3) and the 4th lens group (Gr4) to increase from a wide angle edge (W) to a middle focal distance, and for a middle focal distance to a tele edge (T) to decrease, it is still more desirable when it secures compactability that it is satisfied with this and coincidence of conditional expression (3). Thus, by carrying out zoom migration of the 3rd and 4th lens group (Gr3, Gr4), the

curvature of field of the undershirt generated especially in a middle focal distance field can be amended good, and the zoom lens system which maintained the high engine performance can be realized.

[0032] Moreover, it is desirable for focusing to be performed by migration of the 4th lens group (Gr4) as mentioned above in the zoom lens system of the type which contains forward and a negative, forward, and negative zoom group in order from the body side like the gestalt of each operation, and to satisfy the following conditional expression (4) further. A zoom lens system with the better engine performance is realizable with this. Moreover, it is still more desirable to satisfy conditional expression (4) with said conditional expression (3).

$0.5 < \beta_{W4} < 2$  -- the lateral magnification of the 4th lens group (Gr4) in a (4), however  $\beta_{W4}$ :wide angle edge (W) -- it comes out.

[0033] As mentioned above, the power of the 4th lens group (Gr4) is comparatively weak, therefore lens number of sheets also has few 4th lens groups (Gr4). The 4th lens group with lens weight small as a focal group from this (Gr4) is the optimal. However, when the system in which focusing using an image sensor (SR) is possible can be adopted, even if an image sensor (SR) is made to perform focusing, it does not interfere.

[0034] If the minimum of conditional expression (4) is exceeded, the rate of variable power shared with the 4th lens group (Gr4) in a wide angle edge (W) will become small, and the need of adding a burden to the 3rd lens group (Gr3) will come out. For this reason, removal of many aberration within the 3rd lens group (Gr3) becomes difficult as a result. When the upper limit of conditional expression (4) is exceeded, the burden of the variable power in the 4th lens group (Gr4) becomes large too much, and removal of many aberration within the 4th lens group (Gr4) becomes difficult, consequently it becomes impossible moreover, to realize a compact zoom lens system.

[0035] If the aspheric surface is arranged in the 2nd lens group (Gr2) as mentioned above, the zoom lens system which starts in a wide angle more will be obtained. If the focal distance of a wide angle edge (W) tends to be made smaller and it is going to enlarge a photography field angle, distortion amendment in a wide angle edge (W) will become difficult especially. In order to remove this fault, it is desirable to arrange the aspheric surface in the comparatively high 2nd lens group (Gr2) of the beam-of-light height besides the shaft by the side of a wide angle, and it can amend distortion aberration good by this. Therefore, it is still more desirable to arrange the aspheric surface in the

2nd lens group (Gr2), while filling conditional expression (3) and conditional expression (4), when obtaining high optical-character ability, holding compactability.

[0036] In addition, although each lens group which constitutes the gestalt of the 1st - the 9th operation consists of only refraction mold lenses (that is, lens of the type with which a deviation is performed by the interface of the media which have a different refractive index) which deflect an incident ray by refraction, it is not restricted to this. For example, each lens group may consist of a diffraction mold lens which deflects an incident ray by diffraction, a refraction / diffraction hybrid mold lens which deflects an incident ray in the combination of a diffraction operation and a refraction operation, a gradient index lens which deflects an incident ray according to the refractive-index distribution in a medium.

[0037] Moreover, in the gestalt of each operation, a rear stirrup may bend an optical path on the way before a zoom lens system by arranging the field (for example, a reflector, a refracting interface, a diffraction side) which does not have optical power in an optical path. It is [ that what is necessary is just to set up a bending location if needed ] possible to attain thin shape-ization on the appearance of a camera by proper bending of an optical path. Moreover, it is

also possible to make it the configuration from which the thickness of a camera changes neither with zooming nor collapsing. For example, if the 1st lens group (Gr1) is considered as location immobilization at the time of variable power, a mirror is arranged behind the 1st lens group (Gr1) and 90 degrees of optical paths are bent in the reflector, since the die length of the cross direction of a zoom lens system will become fixed, thin shape-ization of a camera can be attained.

[0038] Furthermore, with the gestalt of each operation, although the example of a configuration of the optical low pass filter of the configuration of the plane-parallel plate (PL) arrange between the last side of a zoom lens system and an image sensor (SR) be showed, as this low pass filter, a birefringence mold low pass filter made from Xtal with which the predetermined crystal orientation be adjusted, the phase mold low pass filter which attain the property of optical cut-off frequency need according to the diffraction effect be applicable.

[0039]

[Example] Construction data, an aberration Fig., etc. are mentioned and the configuration of the zoom lens system hereafter used for the image pick-up lens equipment which carried out this invention etc. is explained still more concretely.

The examples 1-9 given as an example here are equivalent to the gestalt of the 1st - the 9th operation mentioned above, respectively, and the lens block diagram ( drawing 1 - drawing 9 ) showing the gestalt of the 1st - the 9th operation shows the lens configuration of the corresponding examples 1-9, respectively.

[0040] In the construction data of each example,  $r_i$  ( $i = 1, 2$  and  $3, \dots$ ) is counted from a body side. The radius of curvature of the  $i$ -th field (mm), Count  $d_i$  ( $i = 1, 2$  and  $3, \dots$ ) from a body side, and the  $i$ -th axial top-face spacing (mm) is shown. nickel ( $i = 1, 2$  and  $3, \dots$ ) and  $n_{ui}$  ( $i = 1, 2$  and  $3, \dots$ ) are counted from a body side, and show the refractive index ( $N_d$ ) and the Abbe number ( $\nu_d$ ) to d line of the  $i$ -th optical element. Moreover, axial top-face spacing which changes in zooming is adjustable air spacing in a wide angle edge (a short focus distance edge, W) middle (a middle focal distance condition, M) - a tele edge (a long focal distance edge, T) among construction data. The focal distance ( $f$ , mm) and the f number (FNO) of the whole system corresponding to each focal distance condition (W), (M), and (T) are combined with other data, and are shown, and the movement magnitude (focal data) of the 4th lens group (Gr4) in focusing at the time of contiguity (photography distance:  $D = 0.5\text{m}$ ) is shown in Table 1, and the value

corresponding to conditional expression is shown in Table 2.

[0041] It shall be shown that the field where \* mark was given to radius of curvature  $r_i$  is a field which consisted of the aspheric surfaces, and it shall define as the formula (AS) of the following showing the field configuration of the aspheric surface. The aspheric surface data of each example are combined with other data, and are shown.

$X(H) = (C_0, H^2) / \{1 + \sqrt{1 - \epsilon} C_0^2, H^2\} + (A_4, H^4 + A_6, H^6 + A_8 \text{ and } H^8 + A_{10}, H^{10})$  (AS) -- AS Correct. the variation rate of the direction of an optical axis in the inside of a formula (AS), and the location of  $X(H)$ :height  $H$  -- an amount (plane peak point criteria) and  $H$  : an optical axis -- receiving -- the height of a perpendicular direction, and  $C_0$  : Paraxial curvature (= 1/radius of curvature) and  $\epsilon$  : A secondary curved-surface parameter and  $A_i$  : the  $i$ -th aspheric surface multiplier -- it comes out.

[0042] Drawing 10 - drawing 25 are the aberration Figs. of an example 1 - an example 9, and the aberration Fig. in the infinite distance photography condition of an example 1 - an example 9, drawing 19 - drawing 25 of drawing 10 - drawing 18 are the aberration Figs. in examples 1-5 and the contiguity photography condition (photography distance:  $D = 0.5m$ ) of 8 and 9. (W) is

astigmatism and distortion aberration, such as spherical aberration, among drawing 10 - drawing 25 sequentially from the many aberration {left [ in / a wide angle edge and (M), and / in (T) / a tele edge ]. [ middle ] Y': Maximum image quantity (mm)} is shown. In the spherical-aberration Fig., spherical aberration [ as opposed to d line in a continuous line (d) ], spherical aberration [ as opposed to g line in an alternate long and short dash line (g) ], and a broken line (SC) express sine condition. In the astigmatism Fig., the astigmatism over d line in a meridional side is expressed, and, as for the broken line (DM), the continuous line (DS) expresses the astigmatism over d line in a sagittal side. Moreover, in the distortion aberration Fig., the continuous line expresses distortion % to d line.

[0043]

<<example 1>>

f= 7.5 to 25.5 to 50.6, and FNO=2.55-2.96-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 63.832 d1= 1.200 N 1= 1.74000 nu1= 28.26 r2= 46.105 d2= 4.909 N 2= 1.49310 nu2= 83.58 r3= 557.712 d3= 0.100 r4= 41.139 d4= 3.518 N 3= 1.49310 nu3= 83.58 r5= 95.433 d5= 1.000-28.553-40.964 r6= 28.766 d6= 0.800 N 4= 1.80420 nu4= 46.50 r7= 8.145 d7= 6.254 r8= -24.683 d8= 0.800 N 5= 1.80741 nu5= 31.59 r9= 408.759

d9= 2.972 N 6= 1.84666 nu6= 23.82r10= -15.616d10= 0.727r11=-12.222d11= 0.800 N 7= 1.52510 nu7= 56.38r12\*=-72.536 d12=24.622-4.490-1.000r13= infinity (ST) d13= 0.800r14= 11.863d14= 2.033 N 8= 1.78831 nu8= 47.32r15= 212.313 d15= 5.251r16= -66.079 d16= 1.795 N 9= 1.48749 nu9= 70.44r17= -10.997 d17= 0.800 N 10= 1.84666 nu10=23.82r18\*= 29.156 d18= 0.100r19= 12.934 d19= 3.092 N 11= 1.48749 nu11=70.44r20\*=-19.433 d20= 0.100r21=-788.619 d21= 4.662 N 12= 1.79850 nu12=22.60r22= -27.115d22= 1.000-7.000 - 1.000r23= 23.066 d23= 0.800 N 13= 1.85000 nu13=40.04r24= 11.361 d24= 3.500r25=11.740 d25= 1.826 N 14= 1.79850 nu14=22.60r26= 14.538 d26= 2.381-2.000 - 13.578r27= infinity d27= 3.000 N 15= 1.51680 nu15=64.20r28= infinity [0044]

[Page [ 12th ] (r12) aspheric surface data] epsilon=1.0000, A4=-0.90791x10-4, A6=-0.27514x10-6, A8=-0.37035x10-8 [page [ 18th ] (r18) aspheric surface data] epsilon=1.0000, and A4= 0.28853x10-3, A6= 0.12716x10-5, A8= 0.10778x10-7 [page [ 20th ] (r20) aspheric surface data] epsilon=1.0000[0045]

<<example 2>>

f= 7.5 to 25.5 to 50.6, and FNO=2.48-3.07-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 62.012 d1= 1.200 N

1= 1.79850 nu1= 22.60r2= 50.059 d2= 3.893 N 2= 1.49310 nu2= 83.58r3= 264.139 d3= 0.100r4= 57.561 d4= 2.818 N 3= 1.49310 nu3= 83.58r5= 155.066 d5= 1.000-30.739-48.448r6= 29.965 d6= 0.800 N 4= 1.75450 nu4= 51.57r7= 9.032 d7= 7.570r8= -52.559 d8= 0.800 N 5= 1.75450 nu5= 51.57r9=21.530 d9= 4.134 N 6= 1.79850 nu6= 22.60r10= -18.800d10= 0.486r11=-15.910 d11= 0.800 N 7= 1.84666 nu7= 23.82r12\*=-107.564 d12=25.513-4.405-1.000r13= infinity (ST) d13= 0.800r14= 13.086 d14= 1.832 N 8= 1.80750 nu8= 35.43r15= 84.611 d15= 3.644r16= 15.627 d16= 2.756 N 9= 1.75450 nu9= 51.57r17= -12.357 d17= 0.800 N 10= 1.84666 nu10=23.82r18= 9.111 d18= 0.100r19=7.143 d19=1.343 N 11= 1.52510 nu11=56.38r20\*= 13.828 d20= 2.118r21= 31.671 d21= 1.530N 12= 1.79850 nu12=22.60r22= -35.431 d22= 1.000-5.669 - 4.095r23= 26.961 d23= 0.800 N 13= 1.85000 nu13=40.04r24= 9.331 d24= 2.307r25= 11.028 d25= 1.289 N 14= 1.79850 nu14=22.60r26= 14.503 d26= 2.123-2.989-8.644r27=-130.604 d27= 1.347 N 15= 1.79850 nu15=22.60r28= -33.480d28= 0.858r29=infinity d29= 3.000 N 16= 1.51680 nu16=64.20r30= infinity [0046]

[page [ 12th ] (r12) aspheric surface data] -- epsilon= 1.0000 and  
 A4=-0.44023x10 -4 and A6=-0.52908x10 -7, A8=-0.21921x10-8 [page [ 20th ]

(r20) aspheric surface data] epsilon=1.0000, and A4= -- 0.52117x10-3 and A --  
6= 0.41505x10-5 and A -- 8= 0.98968x10-7 [0047]

<<example 3>>

f= 7.4 to 23.0 to 49.5, and FNO=2.22-2.64-3.60 [Radius of curvature] [Axial  
top-face spacing] [Refractive index] The [Abbe number] r1= 63.356 d1= 1.200 N  
1= 1.79850 nu1= 22.60 r2= 49.435 d2= 4.655 N 2= 1.49310 nu2= 83.58 r3=  
579.022 d3= 0.100 r4= 35.101 d4= 4.695 N 3= 1.49310 nu3= 83.58 r5= 120.463  
d5= 1.000-20.900-28.705 r6= 70.488 d6= 0.800 N 4= 1.78831 nu4= 47.32 r7=  
8.526 d7= 5.198 r8= -90.436 d8= 0.800 N 5= 1.75450 nu5= 51.57 r9=-785.404  
d9= 2.674 N 6= 1.84666 nu6= 23.82 r10= -17.628 d10= 0.515 r11=-14.870 d11=  
0.800 N 7= 1.48749 nu7= 70.44 r12= 45.809 d12= 1.366 r13= -26.330 d13=  
1.344 N 8= 1.84666 nu8= 23.82 r14\*=-30.311 d14= 23.018-5.870-1.000 r15=  
infinity (ST) d15= 0.800 r16= 11.633 d16= 2.165 N 9= 1.80420 nu9= 46.50 r17=  
78.024 d17= 4.756 r18=-96.322 d18= 1.561 N 10= 1.75450 nu10= 51.57 r19=  
-14.086 d19= 0.800 N 11= 1.84666 nu11= 23.82 r20\*=-20.484 d20=  
0.155 r21= 10.937 d21= 2.506 N 12= 1.48749 nu12= 70.44 r22\*=-29.274 d22=  
2.186 r23= 90.101 d23= 1.374 N 13= 1.79850 nu13= 22.60 r24= -61.263 d24=  
1.000-4.206 - 1.000 r25= 29.977 d25= 0.800 N 14= 1.85000 nu14= 40.04 r26=

10.683 d26= 3.356r27= 11.252 d27= 1.235 N 15= 1.79850 nu15=22.60r28= 13.786 d28= 1.399-3.217 - 16.734r29= 22.159 d29= 1.546 N 16= 1.79850 nu16=22.60r30= 89.583 d30= 1.176r31=infinity d31= 3.000 N 17= 1.51680 nu17=64.20r32= infinity [0048]

[Page [ 14th ] (r14) aspheric surface data] epsilon=1.0000, A4=-0.55658x10-4, A6=-0.18456x10-6, A8=-0.60664x10-8 [page [ 20th ] (r20) aspheric surface data] epsilon=1.0000, and A4= 0.28248x10-3, A6= 0.17454x10-5, A8= 0.32532x10-7 [page [ 22nd ] (r22) aspheric surface data] epsilon=1.0000[0049]

<<example 4>>

f= 7.4 to 35.9 to 49.6, and FNO=2.88-3.04-3.63 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 60.590 d1= 1.200 N 1= 1.84666 nu1= 23.82r2= 47.616 d2= 5.549 N 2= 1.49310 nu2= 83.58r3= 603.843 d3= 0.100r4= 39.319 d4= 4.325 N 3= 1.49310 nu3= 83.58r5= 105.185 d5= 1.000-32.186-36.134r6= 50.395 d6= 0.800 N 4= 1.85000 nu4= 40.04r7= 8.808 d7= 5.350r8= -22.935 d8= 0.800 N 5= 1.85000 nu5= 40.04r9=16.429 d9= 5.107 N 6= 1.71736 nu6= 29.50r10= -17.500d10= 0.100r11\*= 54.395 d11= 2.000 N 7= 1.84506 nu7=23.66r12= 1000.000 d12= 1.278r13=-19.690 d13= 0.800 N8= 1.75450nu8= 51.57r14= -77.927 d14=22.063-1.444-1.300r15=

infinity (ST) d15= 0.800 r16= 12.783 d16= 2.898 N 9= 1.85000 nu9= 40.04 r17= 105.738 d17= 3.453 r18\*=37.506 d18= 2.226 N 10= 1.84506 nu10=23.66 r19= 9.939 d19= 1.104 r20=12.962 d20= 4.135 N 11= 1.69680 nu11=55.43 r21= -8.915 d21= 0.800 N 12= 1.84666 nu12=23.82 r22=26007.802 d22= 1.396 r23=186.617 d23= 2.183 N 13= 1.83350 nu13=21.00 r24= -21.147 d24= 1.810-6.450-1.000 r25= 38.703 d25= 0.800 N 14= 1.85000 nu14=40.04 r26= 13.436 d26= 4.085 r27= 14.114 d27= 1.362 N 15= 1.83350 nu15=21.00 r28= 18.526 d28= 1.000-5.337 - 17.559 r29= 16.513 d29= 1.967 N 16= 1.48749  
nu16=70.44 r30= 44.597 d30= 1.479 r31= infinity d31= 3.000  
N17=1.51680 nu17=64.20 r32= infinity [0050]

[page [ 11th ] (r11) aspheric surface data] -- epsilon= 1.0000 and A4= 0.40063x10 -4 and A6= 0.39528x10 -6, A8=-0.29922x10-8 [page [ 18th ] (r18) aspheric surface data] epsilon=1.0000, and A4= -0.11545x10-3 and A6= -0.96168x10-6 and A -- 8= 0.16989x10-7 [0051]

<<example 5>>

f= 8.9 to 33.7 to 84.8, and FNO=2.43-3.17-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 171.427 d1= 1.497 N 1= 1.84666 nu1= 23.82 r2= 114.665 d2= 6.918 N 2= 1.49310 nu2= 83.58 r3=

-850.123 d3= 0.100r4= 96.816 d4= 4.523 N 3= 1.49310 nu3= 83.58r5= 348.049  
d5= 2.486-40.898-95.614r6\*= 24.483 d6= 2.000 N 4= 1.75450 nu4= 51.57r7= 12.754 d7= 11.729r8= -33.584 d8= 0.800 N 5= 1.52208 nu5= 65.92r9=21.063  
d9= 4.926 N 6= 1.84705 nu6= 25.00r10= -81.045d10= 0.838r11=-40.184 d11= 0.800 N 7= 1.74495 nu7= 24.47r12= 99.136 d12=41.883-2.565-1.250r13= infinity (ST) d13= 1.500r14= 12.436 d14= 3.485 N 8= 1.75450 nu8= 51.57r15=-172.448 d15= 1.166r16= 375.028 d16= 0.800 N 9= 1.71675 nu9= 26.91r17= 30.185 d17= 1.000-1.169 - 1.244r18\*= 16.888 d18= 1.922 N 10= 1.84666 nu10=23.82r19= 11.475 d19= 1.988-11.017 - 23.820r20\*= 25.613 d20= 0.800 N 11= 1.75000 nu11=25.14r21= 14.963 d21= 0.077r22= 15.312 d22= 1.202 N 12= 1.75450 nu12=51.57r23= 16.980 d23= 0.356r24= 16.249 d24= 6.391 N 13= 1.49310 nu13=83.58r25= -22.015 d25= 1.962r26= -13.823 d26= 3.437 N14=1.84666nu14=23.82r27=-14.151 d27= 2.000-12.427 - 6.704r28\*= 20.728 d28= 2.834 N 15= 1.52510 nu15=56.38r29= 15.822 d29= 1.307r30= infinity d30= 3.000 N 16= 1.51680 nu16=64.20r31= infinity [0052]

[Page [ 6th ] (r6) aspheric surface data] epsilon=1.0000 and A4= 0.66358x10-5, A6= 0.71481x10-9, A8= 0.49766x10-10 [page [ 18th ] (r18) aspheric surface data] epsilon=1.0000, A4=-0.10218x10-3, A6=-0.12797x10-5, and A8=

0.10173x10-7, A10=-0.34395x10-9 [page [ 20th ] (r20) aspheric surface data]

epsilon=1.0000, A4=-0.34705x10-4, A6= 0.10595x10-6, A8=-0.43764x10-8, and

A10= 0.17721x10-10 [page [ 28th ] (r28) aspheric surface data] epsilon=1.0000,

A4=-0.59570x10-5, A6=-0.55853x10-6, A8= 0.11878x10-7,

A10=-0.14101x10-9[0053]

<<example 6>>

f= 7.1 to 53.0 to 68.6, and FNO=2.55-3.60-3.60 [Radius of curvature] [Axial

top-face spacing] [Refractive index] The [Abbe number] r1= 81.309 d1= 1.400 N

1= 1.84666 nu1= 23.86 r2= 63.920 d2= 4.957 N 2= 1.49310 nu2=

83.58 r3=-2566.999 d3= 0.100 r4= 72.424 d4= 2.914 N 3= 1.49310 nu3=

83.58 r5= 204.372 d5= 0.900-54.218-57.909 r6\*=-2187.849 d6= 1.200 N 4=

1.77250 nu4= 49.77 r7\*= 14.815 d7= 8.614 r8= -22.207 d8= 1.500 N 5= 1.84668

nu5= 23.86 r9=-39.485 d9= 0.100 r10= 528.712 d10= 4.283 N 6= 1.84666 nu6=

23.82 r11= -27.851 d11= 1.412 r12= -19.591 d12= 1.000 N 7= 1.49310 nu7=

83.58 r13= -80.805 d13= 40.111-0.619-0.100 r14= infinity (ST) d14= 1.200 r15\*=

20.034 d15= 3.327 N 8= 1.77112 nu8= 48.87 r16= 2658.231 d16=

0.100 r17= 24.453 d17= 1.028 N 9= 1.61287 nu9= 33.36 r18\*= 9.473 d18=

0.432 r19= 12.678 d19= 2.612 N 10= 1.75450 nu10= 51.57 r20= -167.012 d20=

0.537-1.270 - 1.348r21= -32.395 d21= 6.981 N 11= 1.64379 nu11=56.31r22= -11.929 d22= 0.100r23\*=-13.515 d23= 1.708N 12= 1.63456 nu12=31.17r24\*= 24.372 d24= 0.263-19.944 - 27.790r25= 19.740 d25= 4.770 N 13= 1.79850 nu13=22.60r26= 13.053 d26= 0.100r27=13.309 d27= 5.694 N 14= 1.68636 nu14=54.20r28=-129.207 d28= 4.148-5.575 - 2.763r29= infinity d29= 3.000 N 15= 1.51680 nu15=64.20r32= infinity [0054]

[Page [ 6th ] (r6) aspheric surface data] epsilon=1.0000 and A4= 0.29074x10-4, A6=-0.89940x10-7, A8= 0.16625x10-9 [page [ 7th ] (r7) aspheric surface data] epsilon=1.0000, A4= 0.44003x10-5, A6= 0.99743x10-8, the A8=-0.48301x10-9[15th page Aspheric surface data]epsilon=1.0000 of (r15), A4=-0.11178x10-3, A6= 0.10605x10-5, A8=-0.21375x10-7, A10= 0.22240x10-9 [page [ 18th ] (r18) aspheric surface data] epsilon=1.0000, A4=-0.24094x10-3 and A6= 0.11663x10-5, A8=-0.57504x10-7, A10= 0.66415x10-9 [page [ 23rd ] (r23) aspheric surface data] epsilon=1.0000, A4= 0.12224x10-3, A6=-0.66295x10-5, A8=0.74249x10-7 [page [ 24th ] (r24) aspheric surface data] epsilon=1.0000, A4= 0.29363x10-3, A6=-0.57030x10-5, A8= 0.80185x10-7[0055]

<<example 7>>

f= 7.1 to 20.0 to 49.0, and FNO=2.50-3.03-3.66 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 111.111 d1= 1.400 N 1= 1.79850 nu1= 22.60r2= 85.390 d2= 4.303 N 2= 1.49310 nu2= 83.58r3=-1831.972 d3= 0.100r4= 43.431 d4= 4.988 N 3= 1.49310 nu3= 83.58r5= 130.083 d5= 0.900-24.171-43.681r6= 35.035 d6= 1.200 N 4= 1.75450 nu4= 51.57r7= 10.040 d7= 4.791r8= -96.605 d8= 1.100 N 5= 1.75450 nu5= 51.57r9=15.175 d9= 1.925r10\*= 25.398 d10= 3.981N 6= 1.84666 nu6= 23.82r11\*=-43.373 d11= 1.258r12= -15.932 d12= 1.000 N 7= 1.48749 nu7= 70.44r13=-134.899 d13=20.871-5.426-0.600r14= infinity (ST) d14= 0.600r15= 11.251 d15= 2.129 N 8= 1.75450 nu8= 51.57r16= 422.558 d16= 4.585r17\*=-39.509 d17= 1.500 N 9= 1.70395 nu9= 26.41r18\*= 12.891 d18= 0.596r19=12.874 d19= 2.614 N 10= 1.48749 nu10=70.44r20= -14.240 d20= 1.806-1.837-3.682r21=-8157.937 d21= 0.800 N 11= 1.71649 nu11=25.74r22= 13.228 d22= 0.445r23= 13.631 d23= 1.919N 12= 1.48749 nu12=70.44r24= 668.856 d24= 3.002-1.300 - 12.240r25= 31.322 d25= 1.691 N 13= 1.79850 nu13=22.60r26= 217.261 d26= 0.500-9.743 - 7.994r27= 18.461 d27= 4.643 N 14= 1.79850 nu14=22.60r28= -11.955 d28= 0.460 N 15= 1.83724 nu15=30.17r26= 21.532 d29= 0.900r30= infinity d27= 3.000 N 16= 1.51680

nu16=64.20r31= infinity [0056]

The [10th side Aspheric surface data]epsilon=1.0000 of (r10), and A4=0.34767x10-4 and A6= 0.63939x10-7, A8=-0.15659x10-8 [page [ 11th ] (r11) aspheric surface data] epsilon=1.0000, and A4= -0.11239x10-4 and A6=-0.50907x10-7 -- the A8=-0.20881x10-8[17th page Aspheric surface data]epsilon=1.0000 of (r17), A4=-0.53164x10-3, A6= 0.11706x10-4, A8=-0.13639x10-6 [page [ 18th ] (r18) aspheric surface data] epsilon=1.0000, A4=-0.23930x10-3, and A6= 0.14046x10-4, A8=-0.15638x10-6[0057]

<<example 8>>

f= 7.5 to 45.0 to 71.5, and FNO=2.17-2.89-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 65.664 d1= 1.200 N 1= 1.75518 nu1= 29.92r2= 47.591 d2= 5.244 N 2= 1.49310 nu2= 83.58r3= 217.318 d3= 0.100r4= 51.066 d4= 4.398 N 3= 1.49310 nu3= 83.58r5= 185.539 d5= 1.000-45.300-49.091r6= 45.239 d6= 0.800 N 4= 1.75450 nu4= 51.57r7= 10.516 d7= 7.570r8= -40.143 d8= 0.800 N 5= 1.80223 nu5= 44.75r9=23.630 d9= 5.046 N 6= 1.79123 nu6= 22.82r10= -18.887d10= 0.656r11=-15.690 d11= 0.800 N 7= 1.84666 nu7= 23.82r12\*=-43.100 d12=35.757-5.453-1.000r13= infinity (ST) d13= 0.800r14= 13.866 d14= 2.194 N 8= 1.78923 nu8= 46.34r15=

74.387 d15= 5.348r16= 13.726 d16= 3.113 N 9= 1.73284 nu9= 52.33r17= -13.373 d17= 0.800 N 10= 1.84758 nu10=26.81r18= 8.964 d18= 0.100r19=7.206 d19=1.439 N 11= 1.52510 nu11=56.38r20\*= 14.351 d20= 2.601r21= 21.969 d21= 1.379N 12= 1.79850 nu12=22.60r22=-1723.989 d22= 1.000-3.838 - 2.749r23= 342.635 d23= 0.800 N 13= 1.66384 nu13=35.98r24= 8.966 d24= 3.000r25= 24.255 d25= 1.566 N 14= 1.79850 nu14=22.60r26\*= 120.635 d26= 1.000-5.947 - 14.698r27= 25.459 d27= 1.667 N 15= 1.79850  
nu15=22.60r28= 884.189d28= 1.019r29=infinity d29= 3.000 N 16= 1.51680  
nu16=64.20r30= infinity [0058]

[Page [ 12th ] (r12) aspheric surface data] epsilon=1.0000, A4=-0.28880x10-4, A6=-0.39221x10-7, A8=-0.58769x10-9 [page [ 20th ] (r20) aspheric surface data] epsilon=1.0000, and A4= 0.44180x10-3 and A6= 0.35794x10-5, A8= 0.93325x10-7 [page [ 26th ] (r26) aspheric surface data] epsilon=1.0000, A4=-0.73523x10-4, A6=-0.60792x10-6, A8=-0.59550x10-8[0059]

<<example 9>>

f= 7.5 to 54.0 to 86.0, and FNO=2.10-2.84-3.60 [Radius of curvature] [Axial top-face spacing] [Refractive index] The [Abbe number] r1= 90.273 d1= 1.200 N 1= 1.83304 nu1= 41.53r2= 50.609 d2= 6.584 N 2= 1.49310 nu2= 83.58r3=

491.903 d3= 0.100r4= 50.212 d4= 5.970 N 3= 1.49310 nu3= 83.58r5= 293.841  
 d5= 1.000-56.319-60.499r6= 53.739 d6= 0.800 N 4= 1.75450 nu4= 51.57r7= 11.112  
 d7= 7.570r8= -105.475 d8= 0.800 N 5= 1.76442 nu5= 49.91r9=16.958  
 d9= 6.473 N 6= 1.77039 nu6= 23.51r10= -22.262d10= 0.563r11=-19.229 d11= 0.800 N 7= 1.84666 nu7= 23.82r12\*=-140.106 d12=34.166-4.250-1.000r13= infinity (ST) d13= 0.800r14= 14.098 d14= 2.180 N 8= 1.83255 nu8= 41.58r15= 75.309 d15= 4.215r16= 13.256 d16= 3.141 N 9= 1.71070 nu9= 53.17r17= -15.268 d17= 0.800 N 10= 1.80992 nu10=25.83r18= 7.879 d18= 0.274r19=7.000 d19=1.461 N 11= 1.52510 nu11=56.38r20\*= 13.820 d20= 3.133r21= 21.375 d21= 1.301N 12= 1.79850 nu12=22.60r22= 2254.283 d22= 1.000-3.613-1.086r23= 2109.616 d23= 0.800 N 13= 1.64794 nu13=36.75r24= 9.838 d24= 2.907r25= 21.069 d25= 1.316 N 14= 1.79850 nu14=22.60r26\*= 59.731 d26= 1.000-6.745 - 18.339r27= 21.610 d27= 1.710 N 15= 1.84666  
 nu15=23.82r28= 97.515d28= 1.154r29=infinity d31= 3.000 N 16= 1.51680  
 nu16=64.20r30= infinity [0060]

[Page [ 12th ] (r12) aspheric surface data] epsilon=1.0000, A4=-0.26006x10-4,  
 A6=-0.12948x10-7, A8=-0.69799x10-9 [page [ 20th ] (r20) aspheric surface  
 data] epsilon=1.0000, and A4= 0.39398x10-3, A6= 0.33896x10-5, A8=

0.11071x10-6 [page [ 26th ] (r26) aspheric surface data] epsilon=1.0000,

A4=-0.53134x10-4, A6=-0.59377x10-6, and A8= 0.30506x10-8 [0061]

[Table 1]

[0062]

[Table 2]

[0063]

[Effect of the Invention] The image pick-up lens equipment which has the high variable-power zoom lens system which could realize the type which has the performance which exceeds forward, negative, forward, and a forward type by compactability according to this invention, had the high engine performance which a variable-power ratio can use by 7 times to about 10 times, and the f number can use also as optical system for the image sensors of the latest small pixel pitch about by 2.5 to four especially as explained above, and was excellent in compactability is realizable. And if this invention is applied to a digital camera; video camera; digital video unit, a personal computer, a mobile computer, a cellular phone, an information personal digital assistant (PDA), etc. at built-in or

the camera by which external is carried out, it can be contributed to miniaturization of these devices, a raise in variable power, and high performance-ization.

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#### DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]

[Drawing 1] The lens block diagram of the gestalt (example 1) of the 1st operation.

[Drawing 2] The lens block diagram of the gestalt (example 2) of the 2nd operation.

[Drawing 3] The lens block diagram of the gestalt (example 3) of the 3rd operation.

[Drawing 4] The lens block diagram of the gestalt (example 4) of the 4th operation.

[Drawing 5] The lens block diagram of the gestalt (example 5) of the 5th operation.

[Drawing 6] The lens block diagram of the gestalt (example 6) of the 6th operation.

[Drawing 7] The lens block diagram of the gestalt (example 7) of the 7th operation.

[Drawing 8] The lens block diagram of the gestalt (example 8) of the 8th operation.

[Drawing 9] The lens block diagram of the gestalt (example 9) of the 9th

operation.

[Drawing 10] The aberration Fig. in the infinite distance photography condition of an example 1.

[Drawing 11] The aberration Fig. in the infinite distance photography condition of an example 2.

[Drawing 12] The aberration Fig. in the infinite distance photography condition of an example 3.

[Drawing 13] The aberration Fig. in the infinite distance photography condition of an example 4.

[Drawing 14] The aberration Fig. in the infinite distance photography condition of an example 5.

[Drawing 15] The aberration Fig. in the infinite distance photography condition of an example 6.

[Drawing 16] The aberration Fig. in the infinite distance photography condition of an example 7.

[Drawing 17] The aberration Fig. in the infinite distance photography condition of an example 8.

[Drawing 18] The aberration Fig. in the infinite distance photography condition of

an example 9.

[Drawing 19] The aberration Fig. in the contiguity photography condition ( $D=0.5m$ ) of an example 1.

[Drawing 20] The aberration Fig. in the contiguity photography condition ( $D=0.5m$ ) of an example 2.

[Drawing 21] The aberration Fig. in the contiguity photography condition ( $D=0.5m$ ) of an example 3.

[Drawing 22] The aberration Fig. in the contiguity photography condition ( $D=0.5m$ ) of an example 4.

[Drawing 23] The aberration Fig. in the contiguity photography condition ( $D=0.5m$ ) of an example 5.

[Drawing 24] The aberration Fig. in the contiguity photography condition ( $D=0.5m$ ) of an example 8.

[Drawing 25] The aberration Fig. in the contiguity photography condition ( $D=0.5m$ ) of an example 9.

[Drawing 26] The mimetic diagram showing the outline optical configuration of the image pick-up lens equipment concerning this invention.

[Description of Notations]

TL -- Taking-lens system (zoom lens system)

SR -- Image sensor

Gr1 -- The 1st lens group

Gr2 -- The 2nd lens group

Gr3 -- The 3rd lens group

Gr4 -- The 4th lens group

Gr5 -- The 5th lens group

Gr6 -- The 6th lens group

PL -- Glass plate (plane-parallel plate)

ST -- Diaphragm

AX -- Optical axis

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(71)出願人 000006079  
ミノルタ株式会社  
大阪府大阪市中央区安土町二丁目3番13号  
大阪国際ビル  
(72)発明者 萩森 仁  
大阪市中央区安土町二丁目3番13号 大阪  
国際ビル ミノルタ株式会社内  
(72)発明者 河野 哲生  
大阪市中央区安土町二丁目3番13号 大阪  
国際ビル ミノルタ株式会社内  
(74)代理人 100085501  
弁理士 佐野 静夫 (外1名)

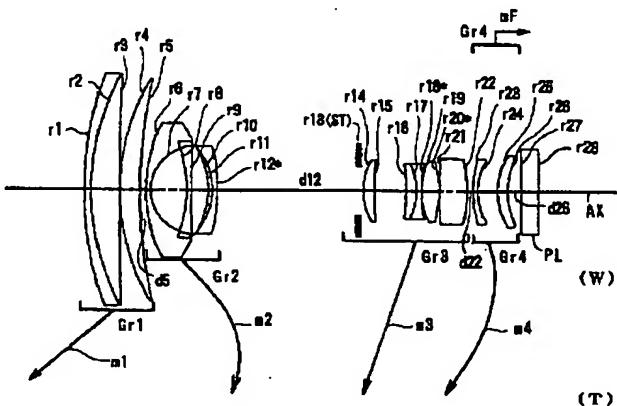
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(54)【発明の名称】撮像レンズ装置

(57)【要約】

【課題】変倍比7倍～10倍程度、Fナンバー2.5～4程度、最先端の小さな画素ピッチの撮像素子用の光学系として使用できる高い性能を持ち、コンパクト性に優れた高変倍ズームレンズ系を有する撮像レンズ装置を提供する。

【解決手段】ズームレンズ系は、物体側より順に、正パワーの第1レンズ群(Gr1)、負パワーの第2レンズ群(Gr2)、正パワーの第3レンズ群(Gr3)、負パワーの第4レンズ群(Gr4)を含み、条件式： $1.1 < f_1/f_T < 2.5$  ( $f_1$ :第1レンズ群(Gr1)の焦点距離,  $f_T$ :望遠端(T)での全系の焦点距離)を満足する。



## 【特許請求の範囲】

【請求項1】 複数のレンズ群から成りレンズ群間隔を変えることにより変倍を行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であつて、

前記ズームレンズ系が、物体側より順に、正のパワーを有する第1レンズ群と、負のパワーを有する第2レンズ群と、正のパワーを有する第3レンズ群と、負のパワーを有する第4レンズ群と、を含み、以下の条件式(1)を満足することを特徴とする撮像レンズ装置；

$$1.1 < f_1 / f_T < 2.5 \quad \dots (1)$$

ただし、

$f_1$ ：第1レンズ群の焦点距離、

$f_T$ ：望遠端での全系の焦点距離、

である。

【請求項2】 前記第4レンズ群が光軸方向に移動することによってフォーカシングが行われ、さらに以下の条件式(2)を満足することを特徴とする請求項1記載の撮像レンズ装置；

$$0.3 < |f_4 / f_T| < 2 \quad \dots (2)$$

ただし、

$f_4$ ：第4レンズ群の焦点距離、

である。

【請求項3】 広角端から望遠端へのズーミングにおいて、前記第1レンズ群が移動し、前記第3レンズ群と前記第4レンズ群との間隔が広角端から中間焦点距離までは増大し中間焦点距離から望遠端までは減少することを特徴とする請求項1又は請求項2記載の撮像レンズ装置。

【請求項4】 複数のレンズ群から成りレンズ群間隔を変えることにより変倍を行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であつて、前記ズームレンズ系が、物体側より順に、正のパワーを有する第1レンズ群と、負のパワーを有する第2レンズ群と、正のパワーを有する第3レンズ群と、負のパワーを有する第4レンズ群と、を含み、ズーミングにおいて第1レンズ群が移動し、以下の条件式(3)を満足することを特徴とする撮像レンズ装置；

$$0.3 < D_{34T} / D_{34W} < 2.5 \quad \dots (3)$$

ただし、

$D_{34T}$ ：広角端における第3レンズ群と第4レンズ群との間の空気間隔、

$D_{34W}$ ：望遠端における第3レンズ群と第4レンズ群との間の空気間隔、

である。

【請求項5】 広角端から望遠端へのズーミングにおいて、前記第4レンズ群が物体側へ移動することを特徴とする請求項4記載の撮像レンズ装置。

10  $0.5 < \beta_w < 2 \quad \dots (4)$

ただし、

$\beta_w$ ：広角端における第4レンズ群の横倍率、である。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は撮像レンズ装置に関するものであり、特に被写体の映像を光学系により光学的に取り込んで撮像素子により電気的な信号として出力する撮像レンズ装置(例えば、デジタルカメラ；ビデオカメラ；デジタルビデオユニット、パソコン 컴퓨터、モバイルコンピュータ、携帯電話、情報携帯端末(PDA:Personal Digital Assistant)等に内蔵又は外付けされるカメラの主たる構成要素)、なかでもコンパクトで高変倍のズームレンズ系を備えた撮像レンズ装置に関するものである。

## 【0002】

【従来の技術】デジタルカメラ用の高変倍ズームレンズとしては、物体側より順に、正のパワーを有する第1レンズ群と、負のパワーを有する第2レンズ群と、正のパワーを有する第3レンズ群と、正のパワーを有する第4レンズ群と、から成るタイプが、従来よりその主流を占めている(例えば特開平4-296809号)。これは正・負・正・正タイプがコンパクト性に優れているためである。

【0003】また、高い変倍比を達成したズームレンズとしては、物体側より順に、正のパワーを有する第1レンズ群と、負のパワーを有する第2レンズ群と、正のパワーを有する第3レンズ群と、負のパワーを有する第4レンズ群と、から成るもの(例えば特開平5-341118号)や、物体側より順に、正のパワーを有する第1レンズ群と、負のパワーを有する第2レンズ群と、正のパワーを有する第3レンズ群と、負のパワーを有する第4レンズ群と、正のパワーを有する第5レンズ群と、から成るもの(例えば特開平10-111457号)も知られている。

## 【0004】

【発明が解決しようとする課題】特開平5-34118号公報で提案されている正・負・正・負タイプのズームレンズは、ズーミングにおいて第1レンズ群が固定であるため、更なる高変倍比化や撮像素子の小ピッチ化に

3  
伴う更なる高性能化には不向きである。また特開平10-111457号公報で提案されている正・負・正・負・正タイプのズームレンズは、ズーミングにおいて第1レンズ群も移動するが、特に第1、第2レンズ群のパワーが強いため各群で発生する諸収差は大きくなる。したがって、更なる高変倍比化や撮像素子の小ピッチ化に伴う更なる高性能化を実現することは困難である。また、第4レンズ群が負群より成る正・負・正・負を含むタイプは、正・負・正・正のタイプと比べてコンパクト性でやや劣るという欠点もある。

【0005】本発明はこのような状況に鑑みてなされたものであって、その目的は、コンパクト性で正・負・正・正タイプを超えるパフォーマンスを持つタイプを実現することにあり、特に、変倍比が7倍～10倍程度、Fナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子用の光学系としても使用できる高い性能を持ち、かつ、コンパクト性に優れた高変倍ズームレンズ系を有する撮像レンズ装置を提供することを目的とする。

#### 【0006】

【課題を解決するための手段】上記目的を達成するために、第1の発明の撮像レンズ装置は、複数のレンズ群から成りレンズ群間隔を変えることにより変倍を行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であって、前記ズームレンズ系が、物体側より順に、正のパワーを有する第1レンズ群と、負のパワーを有する第2レンズ群と、正のパワーを有する第3レンズ群と、負のパワーを有する第4レンズ群と、を含み、以下の条件式(1)を満足することを特徴とする。

$$1.1 < f_1/f_T < 2.5 \quad \dots (1)$$

ただし、

$f_1$ ：第1レンズ群の焦点距離、  
 $f_T$ ：望遠端での全系の焦点距離、  
である。

【0007】第2の発明の撮像レンズ装置は、上記第1の発明の構成において、前記第4レンズ群が光軸方向に移動することによってフォーカシングが行われ、さらに以下の条件式(2)を満足することを特徴とする。

$$0.3 < |f_4/f_T| < 2 \quad \dots (2)$$

ただし、

$f_4$ ：第4レンズ群の焦点距離、  
である。

【0008】第3の発明の撮像レンズ装置は、上記第1又は第2の発明の構成において、広角端から望遠端へのズーミングにおいて、前記第1レンズ群が移動し、前記第3レンズ群と前記第4レンズ群との間隔が広角端から中間焦点距離までは増大し中間焦点距離から望遠端までは減少することを特徴とする。

【0009】第4の発明の撮像レンズ装置は、複数のレンズ群から成りレンズ群間隔を変えることにより変倍を

行うズームレンズ系と、そのズームレンズ系により形成された光学像を電気的な信号に変換する撮像素子と、を備えた撮像レンズ装置であって、前記ズームレンズ系が、物体側より順に、正のパワーを有する第1レンズ群と、負のパワーを有する第2レンズ群と、正のパワーを有する第3レンズ群と、負のパワーを有する第4レンズ群と、を含み、ズーミングにおいて第1レンズ群が移動し、以下の条件式(3)を満足することを特徴とする。

$$0.3 < D_{34L} / D_{34T} < 2.5 \quad \dots (3)$$

10 ただし、

$D_{34L}$ ：広角端における第3レンズ群と第4レンズ群との間の空気間隔、

$D_{34T}$ ：望遠端における第3レンズ群と第4レンズ群との間の空気間隔、  
である。

【0010】第5の発明の撮像レンズ装置は、上記第4の発明の構成において、広角端から望遠端へのズーミングにおいて、前記第4レンズ群が物体側へ移動することを特徴とする。

20 【0011】第6の発明の撮像レンズ装置は、上記第4又は第5の発明の構成において、広角端から望遠端へのズーミングにおいて、前記第3レンズ群と前記第4レンズ群との間隔が広角端から中間焦点距離までは増大し中間焦点距離から望遠端までは減少することを特徴とする。

【0012】第7の発明の撮像レンズ装置は、上記第4、第5又は第6の発明の構成において、フォーカシングが前記第4レンズ群の移動によって行われ、さらによつて以下の条件式(4)を満足することを特徴とする。

$$0.5 < \beta_4 < 2 \quad \dots (4)$$

ただし、

$\beta_4$ ：広角端における第4レンズ群の横倍率、  
である。

#### 【0013】

【発明の実施の形態】以下、本発明を実施した撮像レンズ装置を、図面を参照しつつ説明する。被写体の映像を光学的に取り込んで電気的な信号として出力する撮像レンズ装置は、被写体の静止画撮影や動画撮影に用いられるカメラ{例えば、デジタルカメラ；ビデオカメラ；デジタルビデオユニット、パソコンコンピュータ、モバイルコンピュータ、携帯電話、情報携帯端末(PDA)等に内蔵又は外付けされるカメラ}の主たる構成要素である。その撮像レンズ装置は、例えば図26に示すように、物体(被写体)側から順に、物体の光学像を形成する撮影レンズ系(TL)と、光学的ローパスフィルター等に相当する平行平面板(PL)と、撮影レンズ系(TL)により形成された光学像を電気的な信号に変換する撮像素子(SR)と、で構成される。

【0014】後述する各実施の形態では、複数のレンズ群から成るズームレンズ系が撮影レンズ系(TL)として用

いられ、複数のレンズ群が光軸(AX)に沿って移動し、レンズ群間隔を変えることにより変倍が行われる。撮像素子(SR)としては、例えば複数の画素から成るC C D (Charge Coupled Device)やC M O S (Complementary Metal Oxide Semiconductor)センサー等の固体撮像素子が用いられ、ズームレンズ系により形成された光学像が電気的な信号に変換される。またズームレンズ系で形成されるべき光学像は、撮像素子(SR)の画素ピッチにより決定される所定の遮断周波数特性を有する光学的ローパスフィルター(PL)を通過することにより、電気的な信号に変換される際に発生するいわゆる折り返しノイズが最小化されるように、空間周波数特性が調整される。撮像素子(SR)で生成した信号は、必要に応じて所定のデジタル画像処理や画像圧縮処理等が施されてデジタル映像信号としてメモリー(半導体メモリー、光ディスク等)に記録されたり、場合によってはケーブルを介したり赤外線信号に変換されたりして他の機器に伝送される。

【0015】図1～図9は、第1～第9の実施の形態を構成するズームレンズ系にそれぞれ対応するレンズ構成図であり、広角端(W)でのレンズ配置を光学断面で示している。各レンズ構成図中の矢印mj(j=1, 2, ...)は、広角端(W)から望遠端(T)へのズーミングにおける第jレンズ群(Grj)の移動(ただし破線矢印mjはズーミングにおいて位置固定であることを表す。)をそれぞれ模式的に示しており、矢印mFは無限遠から近接へのフォーカシングにおけるフォーカス群の移動方向を示している。また、各レンズ構成図中、ri(i=1, 2, 3, ...)が付された面は物体(被写体)側から数えてi番目の面であり、riに\*印が付された面は非球面である。di(i=1, 2, 3, ...)が付された軸上面間隔は、物体側から数えてi番目の軸上面間隔のうち、ズーミングにおいて変化する可変間隔である。

【0016】各実施の形態のズームレンズ系はいずれも、物体側より順に、正のパワーを有する第1レンズ群(Gr1)と、負のパワーを有する第2レンズ群(Gr2)と、正のパワーを有する第3レンズ群(Gr3)と、負のパワーを有する第4レンズ群(Gr4)と、を含んでいる。そして、固体撮像素子(例えばC C D)を備えたカメラ(例えばデジタルカメラ)に用いられるズームレンズ系として、その像面側には光学的ローパスフィルター等に相当するガラス製の平行平面板、つまりガラス平板(PL)が配置されている。いずれの実施の形態においても、ガラス平板(PL)はズーミングにおいて位置固定であり、また第3レンズ群(Gr3)は最物体側に絞り(ST)を含んでいる。

【0017】第1の実施の形態のズームレンズ系は、物体側より順に、正のパワーを有する第1レンズ群(Gr1)と、負のパワーを有する第2レンズ群(Gr2)と、正のパワーを有する第3レンズ群(Gr3)と、負のパワーを有する第4レンズ群(Gr4)と、から成る正・負・正・負タイプの4群ズームレンズである。第2～第4、第6、第8、第9の実施の形態のズームレンズ系は、物体側より

順に、正のパワーを有する第1レンズ群(Gr1)と、負のパワーを有する第2レンズ群(Gr2)と、正のパワーを有する第3レンズ群(Gr3)と、負のパワーを有する第4レンズ群(Gr4)と、正のパワーを有する第5レンズ群(Gr5)と、から成る正・負・正・負・正タイプの5群ズームレンズである。

【0018】第5の実施の形態のズームレンズ系は、物体側より順に、正のパワーを有する第1レンズ群(Gr1)と、負のパワーを有する第2レンズ群(Gr2)と、正のパワーを有する第3レンズ群(Gr3)と、負のパワーを有する第4レンズ群(Gr4)と、正のパワーを有する第5レンズ群(Gr5)と、負のパワーを有する第6レンズ群(Gr6)と、から成る正・負・正・負・正・負タイプの6群ズームレンズである。第7の実施の形態のズームレンズ系は、物体側より順に、正のパワーを有する第1レンズ群(Gr1)と、負のパワーを有する第2レンズ群(Gr2)と、正のパワーを有する第3レンズ群(Gr3)と、負のパワーを有する第4レンズ群(Gr4)と、正のパワーを有する第5レンズ群(Gr5)と、正のパワーを有する第6レンズ群(Gr6)と、から成る正・負・正・負・正・正タイプの6群ズームレンズである。

【0019】いずれの実施の形態も、正・負・正・負で始まるズームタイプである。第3、第4レンズ群(Gr3, Gr4)が共に正パワーを有する正・負・正・正タイプと比べると、第4レンズ群(Gr4)を負レンズ群にした正・負・正・負を含むズームタイプでは、第3レンズ群(Gr3)と第4レンズ群(Gr4)のパワーの符号が違うため、第3、第4レンズ群(Gr3, Gr4)でより高い変倍比をさせぐことができ、高変倍を確保しやすいというメリットがある。なお、正・負・正・負を含むタイプとしては、(正・負・正・負)の4群タイプ；(正・負・正・負)・正、(正・負・正・負)・負の5群タイプ；(正・負・正・負)・正・正、(正・負・正・負)・正・負、(正・負・正・負)・負・正、(正・負・正・負)・負・負の6群タイプ等のバリエーションが挙げられる。

【0020】各実施の形態のように物体側より順に正・負・正・負のズーム群を含むタイプのズームレンズ系においては、以下の条件式(1)を満足することが望ましい。これにより、コンパクトで高変倍のズームレンズ系を実現することができる。しかも、変倍比が7倍～10倍程度、Fナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子(SR)用の光学系としても使用できる高い性能を得ることができる。

$$1.1 < f_1/f_T < 2.5 \quad \dots (1)$$

ただし、

f1：第1レンズ群(Gr1)の焦点距離、

fT：望遠端(T)での全系の焦点距離、

である。

【0021】条件式(1)の下限を超えると、第1レンズ群(Gr1)のパワーが強くなりすぎて、特に望遠端(T)にお

ける球面収差を除去することが困難になる。また、条件式(1)の上限を超えると、第1レンズ群(Gr1)のパワーが弱くなりすぎて、特に望遠端(T)でのコンパクト性を確保することが困難になる。

【0022】各実施の形態のように物体側より順に正・負・正・負のズーム群を含むタイプのズームレンズ系においては、第4レンズ群(Gr4)が光軸(AX)方向に移動することによってフォーカシングが行われ、さらに以下の条件式(2)を満足することが望ましい。これによって、より高い性能を確保したズームレンズ系を実現することができる。また、前記条件式(1)と共に条件式(2)を満足することが更に望ましい。

$$0.3 < |f_4/ft| < 2 \quad \cdots (2)$$

ただし、

f4：第4レンズ群(Gr4)の焦点距離、  
である。

【0023】条件式(2)で示されるように第4レンズ群(Gr4)のパワーは比較的弱く、したがってレンズ枚数も第4レンズ群(Gr4)が最も少ない。このことから、レンズ重量の小さい第4レンズ群(Gr4)の光軸(AX)方向の移動(mF)によってフォーカシングを行うのが最適である。ただし、撮像素子(SR)におけるフォーカシングが可能なシステムを採用できるときには、撮像素子(SR)の移動によりフォーカシングを行うようにしても差し支えない。

【0024】条件式(2)の下限を超えると、第4レンズ群(Gr4)のパワーが強くなりすぎて、特に望遠端(T)における近接時の性能劣化を除去することが困難になる。また、条件式(2)の上限を超えると、第4レンズ群(Gr4)のパワーが弱くなりすぎて、フォーカス時の第4レンズ群(Gr4)のレンズ移動量が大きくなりすぎてしまい、鏡胴全体のコンパクト性が損なわれる結果となる。

【0025】また各実施の形態のように、広角端(W)から望遠端(T)へのズーミングにおいて、第1レンズ群(Gr1)が移動し、第3レンズ群(Gr3)と第4レンズ群(Gr4)との間隔が広角端(W)から中間焦点距離までは増大し中間焦点距離から望遠端(T)までは減少することが望ましく、これによってより高変倍のズームレンズ系を実現することができる。また、この特徴的なズーム構成においては条件式(1)や条件式(2)を満足することが更に望ましい。

【0026】従来よりビデオカメラやデジタルカメラに用いられている光学系としては、製品全体として求められるコンパクト性と鏡胴構成の難易度とのバランスから、ズーミングにおいて第1レンズ群(Gr1)が固定されているタイプが主流であった。しかしながら、これからは更なるコンパクトネスと高変倍が求められる状況にあるため、第1レンズ群(Gr1)をズーミングにおいて可動にするのが望ましい。広角端(W)から望遠端(T)へのズーミングにおいて第1レンズ群(Gr1)を物体側へ動かすことにより、望遠端(T)において第2レンズ群(Gr2)に入射

する各光線高さを小さくすることができ、諸収差の補正が行いやすくなる。また、広角端(W)から望遠端(T)へのズーミングにおいて、第3、第4レンズ群(Gr3, Gr4)の間隔が広角端(W)から中間焦点距離までは増大し中間焦点距離から望遠端(T)までは減少する構成とすることにより、中間焦点距離領域における像面湾曲を良好に補正することが可能となり、結果として高変倍のズームレンズ系を実現することができる。

【0027】また各実施の形態のように、第2レンズ群(Gr2)中に非球面を配置することが望ましく、第2レンズ群(Gr2)に非球面を設けることによって、より広角で始まるズームレンズ系が得られる。広角端(W)の焦点距離をより小さくして撮影画角を大きくしようとすると、特に広角端(W)での歪曲補正が困難になる。この不具合を取り除くには、広角側での軸外の光線高さの比較的高い第2レンズ群(Gr2)に非球面を配置することが望ましく、これによって良好に歪曲収差を補正することができる。したがって、条件式(1)や条件式(2)を満たすとともに第2レンズ群(Gr2)中に非球面を配置することが、コンパクト性を保持しながら高い光学性能を得る上で更に望ましい。

【0028】各実施の形態のように物体側より順に正・負・正・負のズーム群を含み、ズーミングにおいて第1レンズ群(Gr1)が移動するズームレンズ系にあっては、以下の条件式(3)を満足することが望ましい。これにより、コンパクトで高変倍のズームレンズ系を実現することができる。しかも、変倍比が7倍～10倍程度、Fナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子(SR)用の光学系としても使用できる高い性能を得ることができる。

$$0.3 < D_{34W} / D_{34T} < 2.5 \quad \cdots (3)$$

ただし、

D<sub>34W</sub>：広角端(W)における第3レンズ群(Gr3)と第4レンズ群(Gr4)との間の空気間隔、

D<sub>34T</sub>：望遠端(T)における第3レンズ群(Gr3)と第4レンズ群(Gr4)との間の空気間隔、

である。

【0029】条件式(3)の下限を超えると、望遠端(T)における第3レンズ群(Gr3)と第4レンズ群(Gr4)との間の空気間隔が大きくなりすぎて、望遠端(T)でのコンパクト性を確保するのが困難になる。また、条件式(3)の上限を超えると、広角端(W)における第3レンズ群(Gr3)と第4レンズ群(Gr4)との間の空気間隔が大きくなりすぎて、広角端(W)でのコンパクト性を確保するのが困難になる。

【0030】各実施の形態のように物体側より順に正・負・正・負のズーム群を含むズームレンズ系においては、前述したようにズーミングにおいて第1レンズ群(Gr1)が移動するだけでなく、広角端(W)から望遠端(T)へのズーミングにおいて、第4レンズ群(Gr4)が物体側へ

移動することが望ましい。これによって、第4レンズ群(Gr4)における変倍比を多くかせぐことができ、より高い変倍比を持ったズームレンズ系を実現することができる。またコンパクト性とのバランスをとる上で、条件式(3)を満たすようにするのが更に好ましい。

【0031】また、各実施の形態のように物体側より順に正・負・正・負のズーム群を含むズームレンズ系においては、前述したように広角端(W)から望遠端(T)へのズーミングにおいて、第3レンズ群(Gr3)と第4レンズ群(Gr4)との間隔が広角端(W)から中間焦点距離までは増大し中間焦点距離から望遠端(T)までは減少することが望ましいが、これと同時に条件式(3)を満足することがコンパクト性を確保する上で更に望ましい。このように第3、第4レンズ群(Gr3, Gr4)をズーム移動させることによって、特に中間焦点距離領域で発生するアンダーの像面湾曲を良好に補正することができ、高い性能を維持したズームレンズ系を実現することができる。

【0032】また各実施の形態のように物体側より順に正・負・正・負のズーム群を含むタイプのズームレンズ系においては、前述したようにフォーカシングが第4レンズ群(Gr4)の移動によって行われ、さらに以下の条件式(4)を満足することが望ましい。これによって、より良好な性能を持ったズームレンズ系を実現することができる。また、前記条件式(3)と共に条件式(4)を満足することが更に望ましい。

$$0.5 < \beta_{\text{W}} < 2 \quad \dots (4)$$

ただし、

$\beta_{\text{W}}$ ：広角端(W)における第4レンズ群(Gr4)の横倍率、である。

【0033】前述したように第4レンズ群(Gr4)のパワーは比較的弱く、したがってレンズ枚数も第4レンズ群(Gr4)が最も少ない。このことから、フォーカス群としてはレンズ重量の小さい第4レンズ群(Gr4)が最適である。ただし、撮像素子(SR)を用いたフォーカシングが可能なシステムを採用できるときには、撮像素子(SR)でフォーカシングを行うようにしても差し支えない。

【0034】条件式(4)の下限を超えると、広角端(W)において第4レンズ群(Gr4)に分担される変倍率が小さくなり、負担を第3レンズ群(Gr3)に付加する必要が出てくる。このため、結果として第3レンズ群(Gr3)内での諸収差の除去が困難になる。また、条件式(4)の上限を超えると、第4レンズ群(Gr4)における変倍の負担が大きくなりすぎて、第4レンズ群(Gr4)内での諸収差の除去が困難になり、その結果、コンパクトなズームレンズ系が実現できなくなる。

【0035】前述したように、第2レンズ群(Gr2)中に非球面を配置すればより広角で始まるズームレンズ系が得られる。広角端(W)の焦点距離をより小さくして撮影画角を大きくしようとすると、特に広角端(W)での歪曲補正が困難になる。この不具合を取り除くには、広角側

での軸外の光線高さの比較的高い第2レンズ群(Gr2)に非球面を配置することが望ましく、これによって良好に歪曲収差を補正することができる。したがって、条件式(3)や条件式(4)を満たすとともに第2レンズ群(Gr2)中に非球面を配置することが、コンパクト性を保持しながら高い光学性能を得る上で更に望ましい。

【0036】なお、第1～第9の実施の形態を構成している各レンズ群は、入射光線を屈折により偏向させる屈折型レンズ(つまり、異なる屈折率を有する媒質同士の界面で偏向が行われるタイプのレンズ)のみで構成されているが、これに限らない。例えば、回折により入射光線を偏向させる回折型レンズ、回折作用と屈折作用との組み合わせで入射光線を偏向させる屈折・回折ハイブリッド型レンズ、入射光線を媒質内の屈折率分布により偏向させる屈折率分布型レンズ等で、各レンズ群を構成してもよい。

【0037】また各実施の形態において、光学的なパワーを有しない面(例えば、反射面、屈折面、回折面)を光路中に配置することにより、ズームレンズ系の前、後又は途中で光路を折り曲げてもよい。折り曲げ位置は必要に応じて設定すればよく、光路の適正な折り曲げにより、カメラの見かけ上の薄型化を達成することが可能である。また、ズーミングや沈胴によりカメラの厚さが変化することのない構成にすることも可能である。例えば、第1レンズ群(Gr1)を変倍時位置固定とし、その第1レンズ群(Gr1)の後ろにミラーを配置し、その反射面で光路を90°折り曲げれば、ズームレンズ系の前後方向の長さが一定になるため、カメラの薄型化を達成することができる。

【0038】さらに各実施の形態では、ズームレンズ系の最終面と撮像素子(SR)との間に配置される平行平面板(PL)の形状の光学的ローパスフィルターの構成例を示したが、このローパスフィルターとしては、所定の結晶軸方向が調整された水晶等を材料とする複屈折型ローパスフィルターや、必要とされる光学的な遮断周波数の特性を回折効果により達成する位相型ローパスフィルター等が適用可能である。

### 【0039】

【実施例】以下、本発明を実施した撮像レンズ装置に用いられるズームレンズ系の構成等を、コンストラクションデータ、収差図等を挙げて、更に具体的に説明する。ここで例として挙げる実施例1～9は、前述した第1～第9の実施の形態にそれぞれ対応しており、第1～第9の実施の形態を表すレンズ構成図(図1～図9)は、対応する実施例1～9のレンズ構成をそれぞれ示している。

【0040】各実施例のコンストラクションデータにおいて、 $r_i$ ( $i=1, 2, 3, \dots$ )は物体側から数えて*i*番目の面の曲率半径(mm)、 $d_i$ ( $i=1, 2, 3, \dots$ )は物体側から数えて*i*番目の軸上面間隔(mm)を示しており、 $N_i$ ( $i=1, 2, 3, \dots$ )、 $v_i$ ( $i=1, 2, 3, \dots$ )は物体側から数えて*i*番目の光学要素の

$d$  線に対する屈折率( $N_d$ )、アッペ数( $\nu_d$ )を示している。また、コンストラクションデータ中、ズーミングにおいて変化する軸上面間隔は、広角端(短焦点距離端,  $W$ )～ミドル(中間焦点距離状態,  $M$ )～望遠端(長焦点距離端,  $T$ )での可変空気間隔である。各焦点距離状態( $W$ ,  $(M)$ ,  $(T)$ )に対応する全系の焦点距離( $f$ , mm)及びFナンバー(FN0)を他のデータと併せて示し、また、近接時(撮影距離:  $D = *$

$$X(H) = (C_0 \cdot H^2) / \{1 + \sqrt{(1 - \varepsilon \cdot C_0^2 \cdot H^2)}\} + (A_4 \cdot H^4 + A_6 \cdot H^6 + A_8 \cdot H^8 + A_{10} \cdot H^{10}) \quad \dots (AS)$$

ただし、式(AS)中、

$X(H)$ : 高さ  $H$  の位置での光軸方向の変位量(面頂点基準)、

$H$ : 光軸に対して垂直な方向の高さ、

$C_0$ : 近軸曲率( $=1/\text{曲率半径}$ )、

$\varepsilon$ : 2次曲面パラメータ、

$A_i$ :  $i$ 次の非球面係数、

である。

【0042】図10～図25は実施例1～実施例9の収差図であり、図10～図18は実施例1～実施例9の無限遠撮影状態での収差図、図19～図25は実施例1～5, 8, 9の近接撮影状態(撮影距離:  $D=0.5m$ )での収差※

#### 《実施例1》

$f=7.5 \sim 25.5 \sim 50.6$ ,  $FN0=2.55 \sim 2.96 \sim 3.60$

[曲率半径] [軸上面間隔] [屈折率] [アッペ数]

$r1=$	63.832	$d1=$	1.200	$N1=$	1.74000	$\nu 1=$	28.26
$r2=$	46.105	$d2=$	4.909	$N2=$	1.49310	$\nu 2=$	83.58
$r3=$	557.712	$d3=$	0.100				
$r4=$	41.139	$d4=$	3.518	$N3=$	1.49310	$\nu 3=$	83.58
$r5=$	95.433	$d5=$	1.000～28.553～40.964				
$r6=$	28.766	$d6=$	0.800	$N4=$	1.80420	$\nu 4=$	46.50
$r7=$	8.145	$d7=$	6.254				
$r8=$	-24.683	$d8=$	0.800	$N5=$	1.80741	$\nu 5=$	31.59
$r9=$	408.759	$d9=$	2.972	$N6=$	1.84666	$\nu 6=$	23.82
$r10=$	-15.616	$d10=$	0.727				
$r11=$	-12.222	$d11=$	0.800	$N7=$	1.52510	$\nu 7=$	56.38
$r12*=$	-72.536	$d12=$	24.622～4.490～1.000				
$r13=$	$\infty(ST)$	$d13=$	0.800				

\*0.5m)のフォーカシングにおける第4レンズ群(Gr4)の移動量(フォーカスデータ)を表1に示し、条件式対応値を表2に示す。

【0041】曲率半径  $r_i$  に\*印が付された面は、非球面で構成された面であることを示し、非球面の面形状を表わす以下の式(AS)で定義されるものとする。各実施例の非球面データを他のデータと併せて示す。

#### 【0043】

10※図である。図10～図25中、( $W$ )は広角端、( $M$ )はミドル、( $T$ )は望遠端における諸収差(左から順に、球面収差等、非点収差、歪曲収差である。 $Y'$ : 最大像高(mm)を示している。球面収差図において、実線(d)は  $d$  線に対する球面収差、一点鎖線(g)は  $g$  線に対する球面収差、破線(SC)は正弦条件を表している。非点収差図において、破線(DM)はメリディオナル面での  $d$  線に対する非点収差を表しており、実線(DS)はサジタル面での  $d$  線に対する非点収差を表わしている。また、歪曲収差図において実線は  $d$  線に対する歪曲%を表している。

r14= 11.863  
           d14= 2.033 N8= 1.78831 v 8= 47.32  
 r15= 212.313  
           d15= 5.251  
 r16= -66.079  
           d16= 1.795 N9= 1.48749 v 9= 70.44  
 r17= -10.997  
           d17= 0.800 N10= 1.84666 v 10= 23.82  
 r18\*= 29.156  
           d18= 0.100  
 r19= 12.934  
           d19= 3.092 N11= 1.48749 v 11= 70.44  
 r20\*= -19.433  
           d20= 0.100  
 r21= -788.619  
           d21= 4.662 N12= 1.79850 v 12= 22.60  
 r22= -27.115  
           d22= 1.000~7.000~1.000  
 r23= 23.066  
           d23= 0.800 N13= 1.85000 v 13= 40.04  
 r24= 11.361  
           d24= 3.500  
 r25= 11.740  
           d25= 1.826 N14= 1.79850 v 14= 22.60  
 r26= 14.538  
           d26= 2.381~2.000~13.578  
 r27= ∞  
           d27= 3.000 N15= 1.51680 v 15= 64.20  
 r28= ∞

【0044】

30

[第12面(r12)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.90791 \times 10^{-4}, A6 = -0.27514 \times 10^{-6}, A8 = -0.37035 \times 10^{-8}$ 

[第18面(r18)の非球面データ]

 $\varepsilon = 1.0000, A4 = 0.28853 \times 10^{-3}, A6 = 0.12716 \times 10^{-5}, A8 = 0.10778 \times 10^{-7}$ 

[第20面(r20)の非球面データ]

 $\varepsilon = 1.0000$ 

【0045】

《実施例2》

f=7.5~25.5~50.6, FN0=2.48~3.07~3.60

[曲率半径] [軸上面間隔] [屈折率] [アッベ数]

r1= 62.012  
           d1= 1.200 N1= 1.79850 v 1= 22.60  
 r2= 50.059  
           d2= 3.893 N2= 1.49310 v 2= 83.58  
 r3= 264.139  
           d3= 0.100  
 r4= 57.561  
           d4= 2.818 N3= 1.49310 v 3= 83.58  
 r5= 155.066  
           d5= 1.000~30.739~48.448

r6= 15  
r6= 29.965  
d6= 0.800 N4= 1.75450 v 4= 51.57  
r7= 9.032  
d7= 7.570  
r8= -52.559  
d8= 0.800 N5= 1.75450 v 5= 51.57  
r9= 21.530  
d9= 4.134 N6= 1.79850 v 6= 22.60  
r10= -18.800  
d10= 0.486  
r11= -15.910  
d11= 0.800 N7= 1.84666 v 7= 23.82  
r12\*=-107.564  
d12=25.513~4.405~1.000  
r13= ∞(ST)  
d13= 0.800  
r14= 13.086  
d14= 1.832 N8= 1.80750 v 8= 35.43  
r15= 84.611  
d15= 3.644  
r16= 15.627  
d16= 2.756 N9= 1.75450 v 9= 51.57  
r17= -12.357  
d17= 0.800 N10=1.84666 v 10=23.82  
r18= 9.111  
d18= 0.100  
r19= 7.143  
d19= 1.343 N11=1.52510 v 11=56.38  
r20\*=-13.828  
d20= 2.118  
r21= 31.671  
d21= 1.530 N12=1.79850 v 12=22.60  
r22= -35.431  
d22= 1.000~5.669~4.095  
r23= 26.961  
d23= 0.800 N13=1.85000 v 13=40.04  
r24= 9.331  
d24= 2.307  
r25= 11.028  
d25= 1.289 N14=1.79850 v 14=22.60  
r26= 14.503  
d26= 2.123~2.989~8.644  
r27= -130.604  
d27= 1.347 N15=1.79850 v 15=22.60  
r28= -33.480  
d28= 0.858  
r29= ∞  
d29= 3.000 N16=1.51680 v 16=64.20  
r30= ∞

17

18

[第12面(r12)の非球面データ]

 $\epsilon = 1.0000, A4 = -0.44023 \times 10^{-4}, A6 = -0.52908 \times 10^{-7}, A8 = -0.21921 \times 10^{-8}$ 

[第20面(r20)の非球面データ]

 $\epsilon = 1.0000, A4 = 0.52117 \times 10^{-3}, A6 = 0.41505 \times 10^{-5}, A8 = 0.98968 \times 10^{-7}$ 

【0047】

## 《実施例3》

f=7.4~23.0~49.5, FN0=2.22~2.64~3.60

[曲率半径] [軸上面間隔] [屈折率] [アッペ数]

r1= 63.356

d1= 1.200 N1= 1.79850 v1= 22.60

r2= 49.435

d2= 4.655 N2= 1.49310 v2= 83.58

r3= 579.022

d3= 0.100

r4= 35.101

d4= 4.695 N3= 1.49310 v3= 83.58

r5= 120.463

d5= 1.000~20.900~28.705

r6= 70.488

d6= 0.800 N4= 1.78831 v4= 47.32

r7= 8.526

d7= 5.198

r8= -90.436

d8= 0.800 N5= 1.75450 v5= 51.57

r9= -785.404

d9= 2.674 N6= 1.84666 v6= 23.82

r10= -17.628

d10= 0.515

r11= -14.870

d11= 0.800 N7= 1.48749 v7= 70.44

r12= 45.809

d12= 1.366

r13= -26.330

d13= 1.344 N8= 1.84666 v8= 23.82

r14\*= -30.311

d14= 23.018~5.870~1.000

r15= ∞(ST)

d15= 0.800

r16= 11.633

d16= 2.165 N9= 1.80420 v9= 46.50

r17= 78.024

d17= 4.756

r18= -96.322

d18= 1.561 N10= 1.75450 v10= 51.57

r19= -14.086

d19= 0.800 N11= 1.84666 v11= 23.82

r20\*= 20.484

d20= 0.155

r21= 10.937

d21= 2.506 N12= 1.48749 v12= 70.44

(11)

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19  
20

r22\*= -29.274  
d22= 2.186  
r23= 90.101  
d23= 1.374 N13=1.79850 v 13=22.60  
r24= -61.263  
d24= 1.000~4.206~1.000  
r25= 29.977  
d25= 0.800 N14=1.85000 v 14=40.04  
r26= 10.683  
d26= 3.356  
r27= 11.252  
d27= 1.235 N15=1.79850 v 15=22.60  
r28= 13.786  
d28= 1.399~3.217~16.734  
r29= 22.159  
d29= 1.546 N16=1.79850 v 16=22.60  
r30= 89.583  
d30= 1.176  
r31= ∞  
d31= 3.000 N17=1.51680 v 17=64.20  
r32= ∞

【0048】

[第14面(r14)の非球面データ]

 $\epsilon = 1.0000, A4=-0.55658 \times 10^{-4}, A6=-0.18456 \times 10^{-6}, A8=-0.60664 \times 10^{-8}$ 

[第20面(r20)の非球面データ]

 $\epsilon = 1.0000, A4=0.28248 \times 10^{-3}, A6=0.17454 \times 10^{-5}, A8=0.32532 \times 10^{-7}$ 

[第22面(r22)の非球面データ]

 $\epsilon = 1.0000$ 

【0049】

《実施例4》

f=7.4~35.9~49.6, FN0=2.88~3.04~3.63

[曲率半径] [軸上面間隔] [屈折率] [アッペ数]

r1= 60.590  
d1= 1.200 N1= 1.84666 v 1= 23.82  
r2= 47.616  
d2= 5.549 N2= 1.49310 v 2= 83.58  
r3= 603.843  
d3= 0.100  
r4= 39.319  
d4= 4.325 N3= 1.49310 v 3= 83.58  
r5= 105.185  
d5= 1.000~32.186~36.134  
r6= 50.395  
d6= 0.800 N4= 1.85000 v 4= 40.04  
r7= 8.808  
d7= 5.350  
r8= -22.935  
d8= 0.800 N5= 1.85000 v 5= 40.04  
r9= 16.429  
d9= 5.107 N6= 1.71736 v 6= 29.50

(12)

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21  
 r10= -17.500  
 d10= 0.100  
 r11\*= 54.395  
 d11= 2.000 N7= 1.84506 v7= 23.66  
 r12= 1000.000  
 d12= 1.278  
 r13= -19.690  
 d13= 0.800 N8= 1.75450 v8= 51.57  
 r14= -77.927  
 d14= 22.063~1.444~1.300  
 r15= ∞(ST)  
 d15= 0.800  
 r16= 12.783  
 d16= 2.898 N9= 1.85000 v9= 40.04  
 r17= 105.738  
 d17= 3.453  
 r18\*= 37.506  
 d18= 2.226 N10= 1.84506 v10= 23.66  
 r19= 9.939  
 d19= 1.104  
 r20= 12.962  
 d20= 4.135 N11= 1.69680 v11= 55.43  
 r21= -8.915  
 d21= 0.800 N12= 1.84666 v12= 23.82  
 r22= 26007.802  
 d22= 1.396  
 r23= 186.617  
 d23= 2.183 N13= 1.83350 v13= 21.00  
 r24= -21.147  
 d24= 1.810~6.450~1.000  
 r25= 38.703  
 d25= 0.800 N14= 1.85000 v14= 40.04  
 r26= 13.436  
 d26= 4.085  
 r27= 14.114  
 d27= 1.362 N15= 1.83350 v15= 21.00  
 r28= 18.526  
 d28= 1.000~5.337~17.559  
 r29= 16.513  
 d29= 1.967 N16= 1.48749 v16= 70.44  
 r30= 44.597  
 d30= 1.479  
 r31= ∞  
 d31= 3.000 N17= 1.51680 v17= 64.20  
 r32= ∞

【0050】

[第11面(r11)の非球面データ]

 $\varepsilon = 1.0000, A4 = 0.40063 \times 10^{-4}, A6 = 0.39528 \times 10^{-6}, A8 = -0.29922 \times 10^{-8}$ 

[第18面(r18)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.11545 \times 10^{-3}, A6 = -0.96168 \times 10^{-6}, A8 = 0.16989 \times 10^{-7}$

【0051】

## 《実施例5》

f=8.9~33.7~84.8, FN0=2.43~3.17~3.60

[曲率半径] [軸上面間隔] [屈折率] [アッベ数]

r1= 171.427

d1= 1.497 N1= 1.84666 v1= 23.82

r2= 114.665

d2= 6.918 N2= 1.49310 v2= 83.58

r3= -850.123

d3= 0.100

r4= 96.816

d4= 4.523 N3= 1.49310 v3= 83.58

r5= 348.049

d5= 2.486~40.898~95.614

r6\*= 24.483

d6= 2.000 N4= 1.75450 v4= 51.57

r7= 12.754

d7= 11.729

r8= -33.584

d8= 0.800 N5= 1.52208 v5= 65.92

r9= 21.063

d9= 4.926 N6= 1.84705 v6= 25.00

r10= -81.045

d10= 0.838

r11= -40.184

d11= 0.800 N7= 1.74495 v7= 24.47

r12= 99.136

d12= 41.883~2.565~1.250

r13= ∞(ST)

d13= 1.500

r14= 12.436

d14= 3.485 N8= 1.75450 v8= 51.57

r15= -172.448

d15= 1.166

r16= 375.028

d16= 0.800 N9= 1.71675 v9= 26.91

r17= 30.185

d17= 1.000~1.169~1.244

r18\*= 16.888

d18= 1.922 N10= 1.84666 v10= 23.82

r19= 11.475

d19= 1.988~11.017~23.820

r20\*= 25.613

d20= 0.800 N11= 1.75000 v11= 25.14

r21= 14.963

d21= 0.077

r22= 15.312

d22= 1.202 N12= 1.75450 v12= 51.57

r23= 16.980

d23= 0.356

(14)

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	25
r24=	16.249
	d24= 6.391 N13=1.49310 v 13=83.58
r25=	-22.015
	d25= 1.962
r26=	-13.823
	d26= 3.437 N14=1.84666 v 14=23.82
r27=	-14.151
	d27= 2.000~12.427~6.704
r28*=	20.728
	d28= 2.834 N15=1.52510 v 15=56.38
r29=	15.822
	d29= 1.307
r30=	$\infty$
	d30= 3.000 N16=1.51680 v 16=64.20
r31=	$\infty$

## 【0052】

[第6面(r6)の非球面データ]

 $\varepsilon = 1.0000, A4 = 0.66358 \times 10^{-5}, A6 = 0.71481 \times 10^{-9}, A8 = 0.49766 \times 10^{-10}$ 

[第18面(r18)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.10218 \times 10^{-3}, A6 = -0.12797 \times 10^{-5}, A8 = 0.10173 \times 10^{-7}, A10 = -0.34395 \times 10^{-9}$ 

[第20面(r20)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.34705 \times 10^{-4}, A6 = 0.10595 \times 10^{-6}, A8 = -0.43764 \times 10^{-8}, A10 = 0.17721 \times 10^{-10}$ 

[第28面(r28)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.59570 \times 10^{-5}, A6 = -0.55853 \times 10^{-6}, A8 = 0.11878 \times 10^{-7}, A10 = -0.14101 \times 10^{-9}$ 

## 【0053】

《実施例6》

 $f = 7.1 \sim 53.0 \sim 68.6, FN0 = 2.55 \sim 3.60 \sim 3.60$ 

[曲率半径] [軸上面間隔] [屈折率] [アッペ数]

r1=	81.309
	d1= 1.400 N1= 1.84666 v 1= 23.86
r2=	63.920
	d2= 4.957 N2= 1.49310 v 2= 83.58
r3=	-2566.999
	d3= 0.100
r4=	72.424
	d4= 2.914 N3= 1.49310 v 3= 83.58
r5=	204.372
	d5= 0.900~54.218~57.909
r6*=	-2187.849
	d6= 1.200 N4= 1.77250 v 4= 49.77
r7*=	14.815
	d7= 8.614
r8=	-22.207
	d8= 1.500 N5= 1.84668 v 5= 23.86
r9=	-39.485
	d9= 0.100
r10=	528.712

27

28

d10= 4.283 N6= 1.84666 v6= 23.82  
 r11= -27.851 d11= 1.412  
 r12= -19.591 d12= 1.000 N7= 1.49310 v7= 83.58  
 r13= -80.805 d13= 40.111~0.619~0.100  
 r14= ∞(ST) d14= 1.200  
 r15\*= 20.034 d15= 3.327 N8= 1.77112 v8= 48.87  
 r16= 2658.231 d16= 0.100  
 r17= 24.453 d17= 1.028 N9= 1.61287 v9= 33.36  
 r18\*= 9.473 d18= 0.432  
 r19= 12.678 d19= 2.612 N10= 1.75450 v10= 51.57  
 r20= -167.012 d20= 0.537~1.270~1.348  
 r21= -32.395 d21= 6.981 N11= 1.64379 v11= 56.31  
 r22= -11.929 d22= 0.100  
 r23\*= -13.515 d23= 1.708 N12= 1.63456 v12= 31.17  
 r24\*= 24.372 d24= 0.263~19.944~27.790  
 r25= 19.740 d25= 4.770 N13= 1.79850 v13= 22.60  
 r26= 13.053 d26= 0.100  
 r27= 13.309 d27= 5.694 N14= 1.68636 v14= 54.20  
 r28= -129.207 d28= 4.148~5.575~2.763  
 r29= ∞ d29= 3.000 N15= 1.51680 v15= 64.20  
 r32= ∞

## 【0054】

[第6面(r6)の非球面データ]

$$\varepsilon = 1.0000, A4 = 0.29074 \times 10^{-4}, A6 = -0.89940 \times 10^{-7}, A8 = 0.16625 \times 10^{-9}$$

[第7面(r7)の非球面データ]

$$\varepsilon = 1.0000, A4 = 0.44003 \times 10^{-5}, A6 = 0.99743 \times 10^{-8}, A8 = -0.48301 \times 10^{-9}$$

[第15面(r15)の非球面データ]

$$\varepsilon = 1.0000, A4 = -0.11178 \times 10^{-3}, A6 = 0.10605 \times 10^{-5}, A8 = -0.21375 \times 10^{-7}, A10 = 0.22240 \times 10^{-9}$$

[第18面(r18)の非球面データ]

$$\varepsilon = 1.0000, A4 = -0.24094 \times 10^{-3}, A6 = 0.11663 \times 10^{-5}, A8 = -0.57504 \times 10^{-7},$$

$A_{10} = 0.66415 \times 10^{-9}$

[第23面(r23)の非球面データ]

$\epsilon = 1.0000, A_4 = 0.12224 \times 10^{-3}, A_6 = -0.66295 \times 10^{-5}, A_8 = 0.74249 \times 10^{-7}$

[第24面(r24)の非球面データ]

$\epsilon = 1.0000, A_4 = 0.29363 \times 10^{-3}, A_6 = -0.57030 \times 10^{-5}, A_8 = 0.80185 \times 10^{-7}$

【0055】

《実施例7》

$f = 7.1 \sim 20.0 \sim 49.0, FNO = 2.50 \sim 3.03 \sim 3.66$

[曲率半径] [軸上面間隔] [屈折率] [アッペ数]

$r1 = 111.111$	$d1 = 1.400$	$N1 = 1.79850$	$v1 = 22.60$
$r2 = 85.390$	$d2 = 4.303$	$N2 = 1.49310$	$v2 = 83.58$
$r3 = -1831.972$	$d3 = 0.100$		
$r4 = 43.431$	$d4 = 4.988$	$N3 = 1.49310$	$v3 = 83.58$
$r5 = 130.083$	$d5 = 0.900 \sim 24.171 \sim 43.681$		
$r6 = 35.035$	$d6 = 1.200$	$N4 = 1.75450$	$v4 = 51.57$
$r7 = 10.040$	$d7 = 4.791$		
$r8 = -96.605$	$d8 = 1.100$	$N5 = 1.75450$	$v5 = 51.57$
$r9 = 15.175$	$d9 = 1.925$		
$r10* = 25.398$	$d10 = 3.981$	$N6 = 1.84666$	$v6 = 23.82$
$r11* = -43.373$	$d11 = 1.258$		
$r12 = -15.932$	$d12 = 1.000$	$N7 = 1.48749$	$v7 = 70.44$
$r13 = -134.899$	$d13 = 20.871 \sim 5.426 \sim 0.600$		
$r14 = \infty(ST)$	$d14 = 0.600$		
$r15 = 11.251$	$d15 = 2.129$	$N8 = 1.75450$	$v8 = 51.57$
$r16 = 422.558$	$d16 = 4.585$		
$r17* = -39.509$	$d17 = 1.500$	$N9 = 1.70395$	$v9 = 26.41$
$r18* = 12.891$	$d18 = 0.596$		
$r19 = 12.874$	$d19 = 2.614$	$N10 = 1.48749$	$v10 = 70.44$
$r20 = -14.240$	$d20 = 1.806 \sim 1.837 \sim 3.682$		
$r21 = -8157.937$			

31

32

d21= 0.800 N11=1.71649 v 11=25.74  
 r22= 13.228 d22= 0.445  
 r23= 13.631 d23= 1.919 N12=1.48749 v 12=70.44  
 r24= 668.856 d24= 3.002~1.300~12.240  
 r25= 31.322 d25= 1.691 N13=1.79850 v 13=22.60  
 r26= 217.261 d26= 0.500~9.743~7.994  
 r27= 18.461 d27= 4.643 N14=1.79850 v 14=22.60  
 r28= -11.955 d28= 0.460 N15=1.83724 v 15=30.17  
 r29= 21.532 d29= 0.900  
 r30= ∞ d27= 3.000 N16=1.51680 v 16=64.20  
 r31= ∞

## 【0056】

[第10面(r10)の非球面データ]

 $\varepsilon = 1.0000, A4 = 0.34767 \times 10^{-4}, A6 = 0.63939 \times 10^{-7}, A8 = -0.15659 \times 10^{-8}$ 

[第11面(r11)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.11239 \times 10^{-4}, A6 = -0.50907 \times 10^{-7}, A8 = -0.20881 \times 10^{-8}$ 

[第17面(r17)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.53164 \times 10^{-3}, A6 = 0.11706 \times 10^{-4}, A8 = -0.13639 \times 10^{-6}$ 

[第18面(r18)の非球面データ]

 $\varepsilon = 1.0000, A4 = -0.23930 \times 10^{-3}, A6 = 0.14046 \times 10^{-4}, A8 = -0.15638 \times 10^{-6}$ 

## 【0057】《実施例8》

30

f=7.5~45.0~71.5, FN0=2.17~2.89~3.60  
 [曲率半径] [軸上面間隔] [屈折率] [アッペ数]  
 r1= 65.664 d1= 1.200 N1= 1.75518 v 1= 29.92  
 r2= 47.591 d2= 5.244 N2= 1.49310 v 2= 83.58  
 r3= 217.318 d3= 0.100  
 r4= 51.066 d4= 4.398 N3= 1.49310 v 3= 83.58  
 r5= 185.539 d5= 1.000~45.300~49.091  
 r6= 45.239 d6= 0.800 N4= 1.75450 v 4= 51.57  
 r7= 10.516 d7= 7.570  
 r8= -40.143 d8= 0.800 N5= 1.80223 v 5= 44.75  
 r9= 23.630 d9= 5.046 N6= 1.79123 v 6= 22.82

33  
 r10= -18.887  
 d10= 0.656  
 r11= -15.690  
 d11= 0.800 N7= 1.84666 v7= 23.82  
 r12\*= -43.100  
 d12= 35.757~5.453~1.000  
 r13=  $\infty$ (ST)  
 d13= 0.800  
 r14= 13.866  
 d14= 2.194 N8= 1.78923 v8= 46.34  
 r15= 74.387  
 d15= 5.348  
 r16= 13.726  
 d16= 3.113 N9= 1.73284 v9= 52.33  
 r17= -13.373  
 d17= 0.800 N10= 1.84758 v10= 26.81  
 r18= 8.964  
 d18= 0.100  
 r19= 7.206  
 d19= 1.439 N11= 1.52510 v11= 56.38  
 r20\*= 14.351  
 d20= 2.601  
 r21= 21.969  
 d21= 1.379 N12= 1.79850 v12= 22.60  
 r22=-1723.989  
 d22= 1.000~3.838~2.749  
 r23= 342.635  
 d23= 0.800 N13= 1.66384 v13= 35.98  
 r24= 8.966  
 d24= 3.000  
 r25= 24.255  
 d25= 1.566 N14= 1.79850 v14= 22.60  
 r26\*= 120.635  
 d26= 1.000~5.947~14.698  
 r27= 25.459  
 d27= 1.667 N15= 1.79850 v15= 22.60  
 r28= 884.189  
 d28= 1.019  
 r29=  $\infty$   
 d29= 3.000 N16= 1.51680 v16= 64.20  
 r30=  $\infty$

## 【0058】

[第12面(r12)の非球面データ]

$$\varepsilon = 1.0000, A4 = -0.28880 \times 10^{-4}, A6 = -0.39221 \times 10^{-7}, A8 = -0.58769 \times 10^{-9}$$

[第20面(r20)の非球面データ]

$$\varepsilon = 1.0000, A4 = 0.44180 \times 10^{-3}, A6 = 0.35794 \times 10^{-5}, A8 = 0.93325 \times 10^{-7}$$

[第26面(r26)の非球面データ]

$$\varepsilon = 1.0000, A4 = -0.73523 \times 10^{-4}, A6 = -0.60792 \times 10^{-6}, A8 = -0.59550 \times 10^{-8}$$

## 【0059】

《実施例9》

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$f=7.5 \sim 54.0 \sim 86.0$ ,  $FNO=2.10 \sim 2.84 \sim 3.60$   
 [曲率半径] [軸上面間隔] [屈折率] [アッベ数]  
 r1= 90.273  
     d1= 1.200 N1= 1.83304 v1= 41.53  
 r2= 50.609  
     d2= 6.584 N2= 1.49310 v2= 83.58  
 r3= 491.903  
     d3= 0.100  
 r4= 50.212  
     d4= 5.970 N3= 1.49310 v3= 83.58  
 r5= 293.841  
     d5= 1.000~56.319~60.499  
 r6= 53.739  
     d6= 0.800 N4= 1.75450 v4= 51.57  
 r7= 11.112  
     d7= 7.570  
 r8= -105.475  
     d8= 0.800 N5= 1.76442 v5= 49.91  
 r9= 16.958  
     d9= 6.473 N6= 1.77039 v6= 23.51  
 r10= -22.262  
     d10= 0.563  
 r11= -19.229  
     d11= 0.800 N7= 1.84666 v7= 23.82  
 r12\*=-140.106  
     d12= 34.166~4.250~1.000  
 r13=  $\infty$ (ST)  
     d13= 0.800  
 r14= 14.098  
     d14= 2.180 N8= 1.83255 v8= 41.58  
 r15= 75.309  
     d15= 4.215  
 r16= 13.256  
     d16= 3.141 N9= 1.71070 v9= 53.17  
 r17= -15.268  
     d17= 0.800 N10= 1.80992 v10= 25.83  
 r18= 7.879  
     d18= 0.274  
 r19= 7.000  
     d19= 1.461 N11= 1.52510 v11= 56.38  
 r20\*=-13.820  
     d20= 3.133  
 r21= 21.375  
     d21= 1.301 N12= 1.79850 v12= 22.60  
 r22= 2254.283  
     d22= 1.000~3.613~1.086  
 r23= 2109.616  
     d23= 0.800 N13= 1.64794 v13= 36.75  
 r24= 9.838  
     d24= 2.907

37  
r25= 21.069  
d25= 1.316 N14=1.79850 v14=22.60  
r26\*= 59.731  
d26= 1.000~6.745~18.339  
r27= 21.610  
d27= 1.710 N15=1.84666 v15=23.82  
r28= 97.515  
d28= 1.154  
r29= ∞  
d31= 3.000 N16=1.51680 v16=64.20  
r30= ∞

## 【0060】

[第12面(r12)の非球面データ]

$$\varepsilon = 1.0000, A4 = -0.26006 \times 10^{-4}, A6 = -0.12948 \times 10^{-7}, A8 = -0.69799 \times 10^{-9}$$

[第20面(r20)の非球面データ]

$$\varepsilon = 1.0000, A4 = 0.39398 \times 10^{-3}, A6 = 0.33896 \times 10^{-5}, A8 = 0.11071 \times 10^{-6}$$

[第26面(r26)の非球面データ]

$$\varepsilon = 1.0000, A4 = -0.53134 \times 10^{-4}, A6 = -0.59377 \times 10^{-6}, A8 = 0.30506 \times 10^{-8}$$

## 【0061】

\* \* 【表1】  
《フォーカスデータ》

フォーカス群：第4レンズ群(Gr4)				
撮影距離(物点～像面)：D = 0.5(m)				
	フォーカス群の移動量			フォーカス群の移動方向
	W	M	T	
実施例 1	0.29	3.717	5.181	像面側
実施例 2	0.144	1.448	3.372	像面側
実施例 3	0.172	1.380	4.638	像面側
実施例 4	0.234	3.393	3.349	像面側
実施例 5	0.264	2.549	9.552	物体側
実施例 6	0.163	5.238	7.961	物体側
実施例 7	0.314	1.929	8.601	像面側
実施例 8	0.133	2.754	4.258	像面側
実施例 9	0.165	4.251	5.783	像面側

## 【0062】

【表2】

## 《条件式対応値》

	条件式(1)	条件式(2)	条件式(3)	条件式(4)
	$f_1/f_T$	$ f_4/f_T $	$D_{34w}/D_{34T}$	$\beta_{w4}$
実施例 1	1.65	0.95	1.00	1.20
実施例 2	1.90	0.69	0.28	1.35
実施例 3	1.30	0.60	1.00	1.34
実施例 4	1.48	0.86	1.81	1.36
実施例 5	1.93	0.60	0.80	1.63
実施例 6	1.54	0.38	0.40	2.36
実施例 7	1.27	0.79	0.37	1.40
実施例 8	1.30	0.35	0.36	1.58
実施例 9	1.21	0.32	0.92	1.52

## 【0063】

【発明の効果】以上説明したように本発明によれば、コンパクト性で正・負・正・正タイプを超えるパフォーマンスを持つタイプを実現することができ、特に、変倍比が7倍～10倍程度、Fナンバーが2.5～4程度で、最先端の小さな画素ピッチの撮像素子用の光学系としても使用できる高い性能を持ち、かつ、コンパクト性に優れた高変倍ズームレンズ系を有する撮像レンズ装置を実現することができる。そして本発明を、デジタルカメラ；ビデオカメラ；デジタルビデオユニット、パソコン用コンピュータ、モバイルコンピュータ、携帯電話、情報携帯端末(PDA)等に内蔵又は外付けされるカメラに適用すれば、これらの機器のコンパクト化、高変倍化及び高性能化に寄与することができる。

## 【図面の簡単な説明】

- 【図1】第1の実施の形態(実施例1)のレンズ構成図。
- 【図2】第2の実施の形態(実施例2)のレンズ構成図。
- 【図3】第3の実施の形態(実施例3)のレンズ構成図。
- 【図4】第4の実施の形態(実施例4)のレンズ構成図。
- 【図5】第5の実施の形態(実施例5)のレンズ構成図。
- 【図6】第6の実施の形態(実施例6)のレンズ構成図。
- 【図7】第7の実施の形態(実施例7)のレンズ構成図。
- 【図8】第8の実施の形態(実施例8)のレンズ構成図。
- 【図9】第9の実施の形態(実施例9)のレンズ構成図。
- 【図10】実施例1の無限遠撮影状態での収差図。
- 【図11】実施例2の無限遠撮影状態での収差図。
- 【図12】実施例3の無限遠撮影状態での収差図。
- 【図13】実施例4の無限遠撮影状態での収差図。
- 【図14】実施例5の無限遠撮影状態での収差図。
- 【図15】実施例6の無限遠撮影状態での収差図。
- 【図16】実施例7の無限遠撮影状態での収差図。

【図17】実施例8の無限遠撮影状態での収差図。

【図18】実施例9の無限遠撮影状態での収差図。

【図19】実施例1の近接撮影状態(D=0.5m)での収差図。

20 【図20】実施例2の近接撮影状態(D=0.5m)での収差図。

【図21】実施例3の近接撮影状態(D=0.5m)での収差図。

【図22】実施例4の近接撮影状態(D=0.5m)での収差図。

【図23】実施例5の近接撮影状態(D=0.5m)での収差図。

【図24】実施例8の近接撮影状態(D=0.5m)での収差図。

30 【図25】実施例9の近接撮影状態(D=0.5m)での収差図。

【図26】本発明に係る撮像レンズ装置の概略光学構成を示す模式図。

## 【符号の説明】

TL …撮影レンズ系(ズームレンズ系)

SR …撮像素子

Gr1 …第1レンズ群

Gr2 …第2レンズ群

Gr3 …第3レンズ群

40 Gr4 …第4レンズ群

Gr5 …第5レンズ群

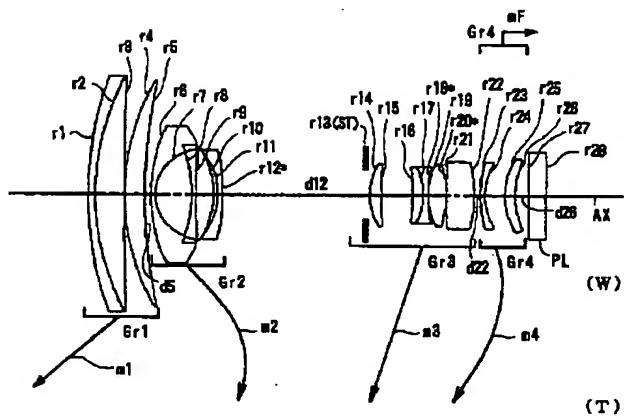
Gr6 …第6レンズ群

PL …ガラス平板(平行平面板)

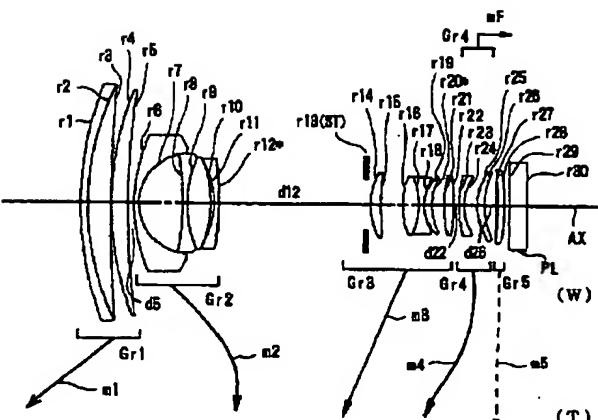
ST …絞り

AX …光軸

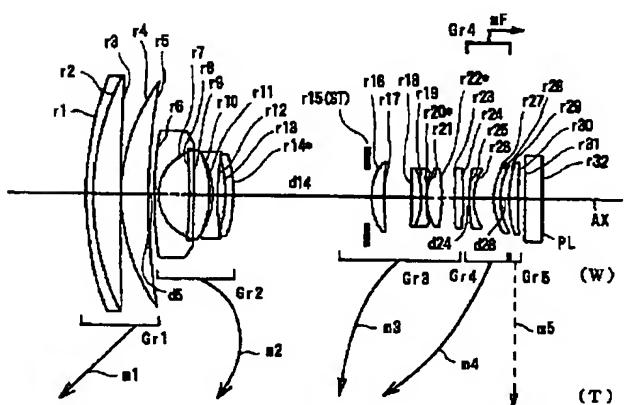
【図1】



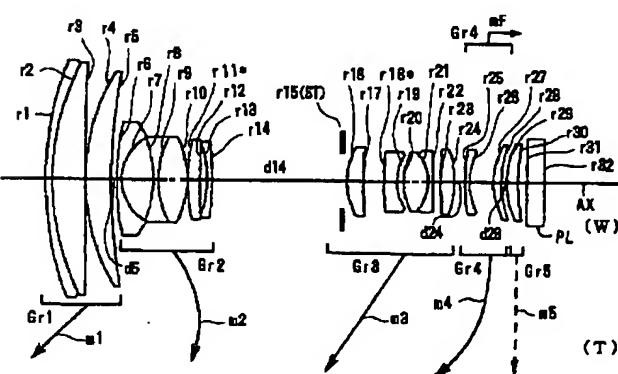
【図2】



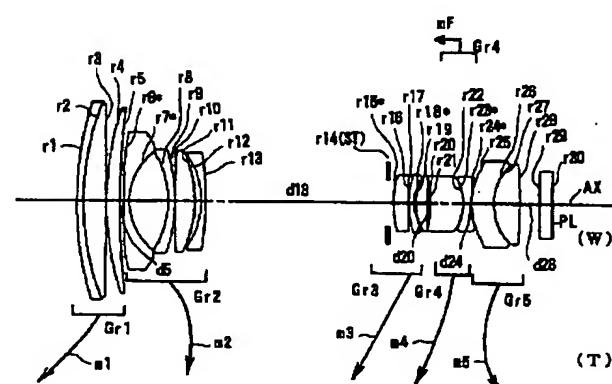
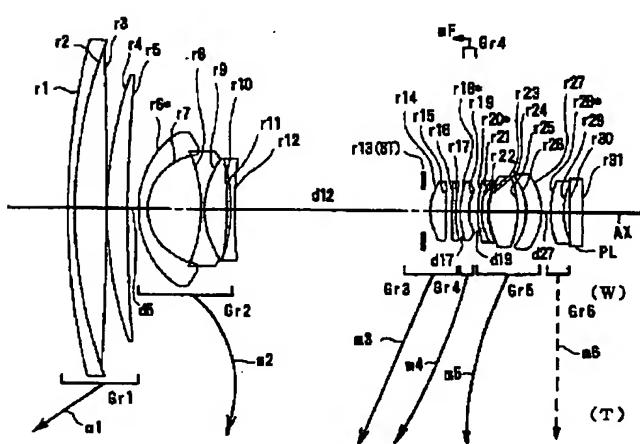
【図3】



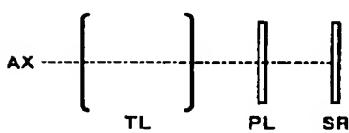
【図4】



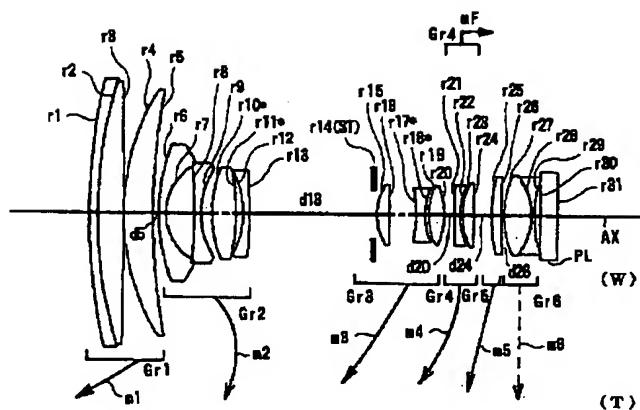
【図5】



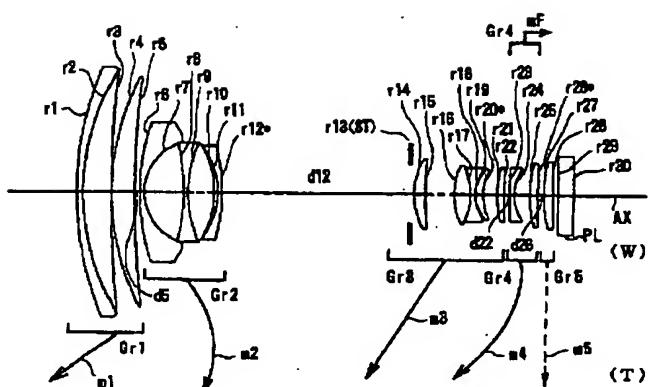
【図26】



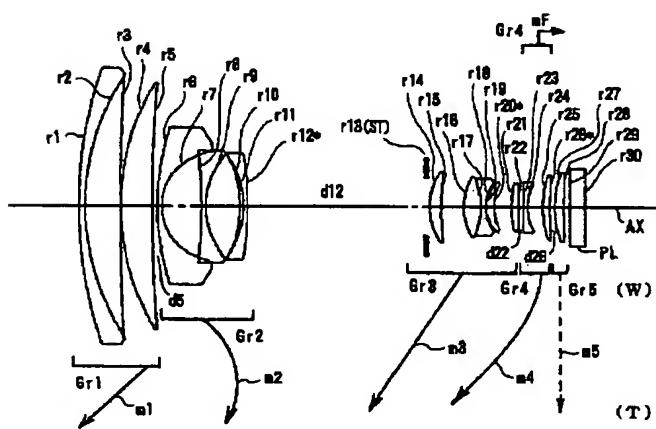
【図7】



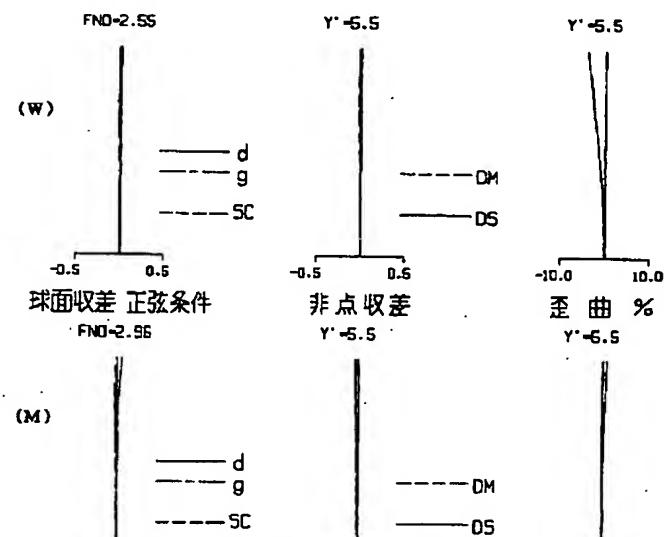
【図8】



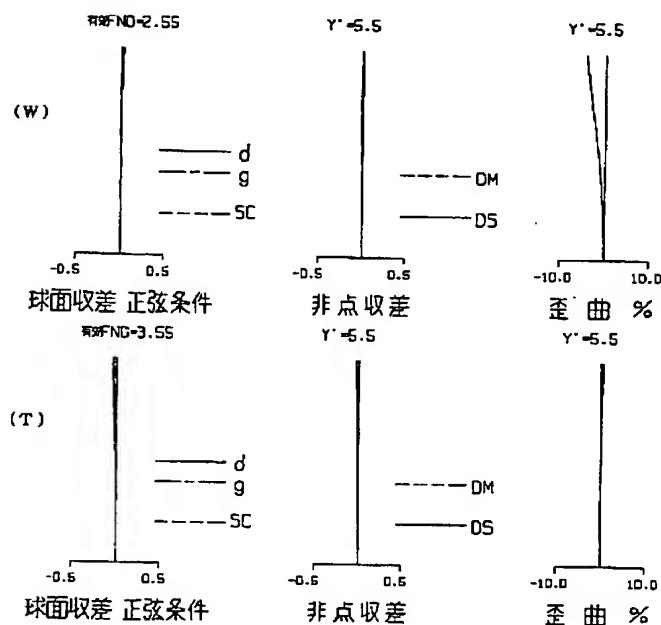
【図9】



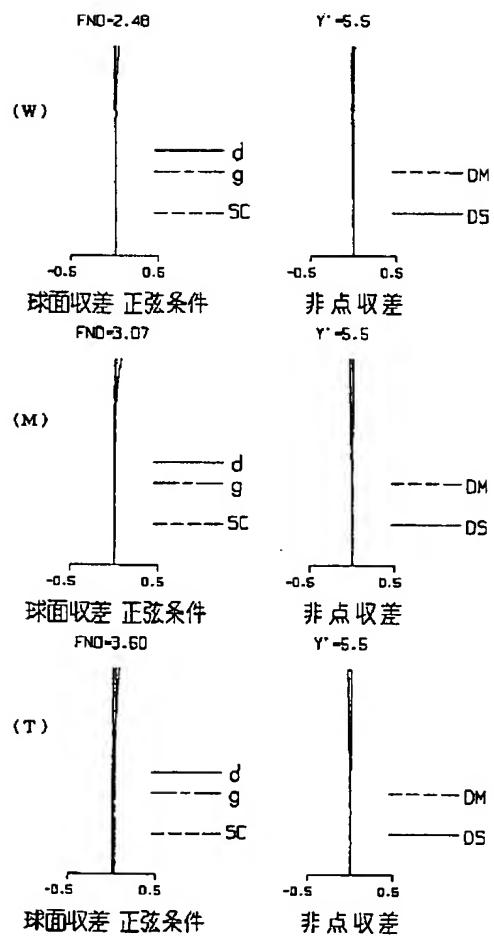
【図10】



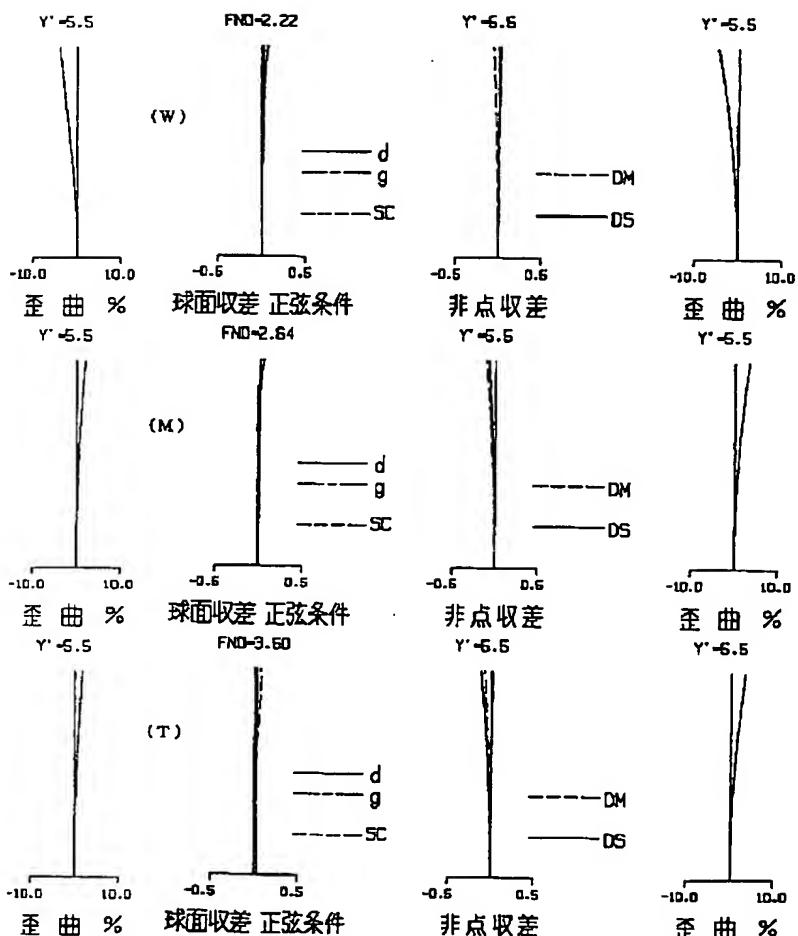
【図19】



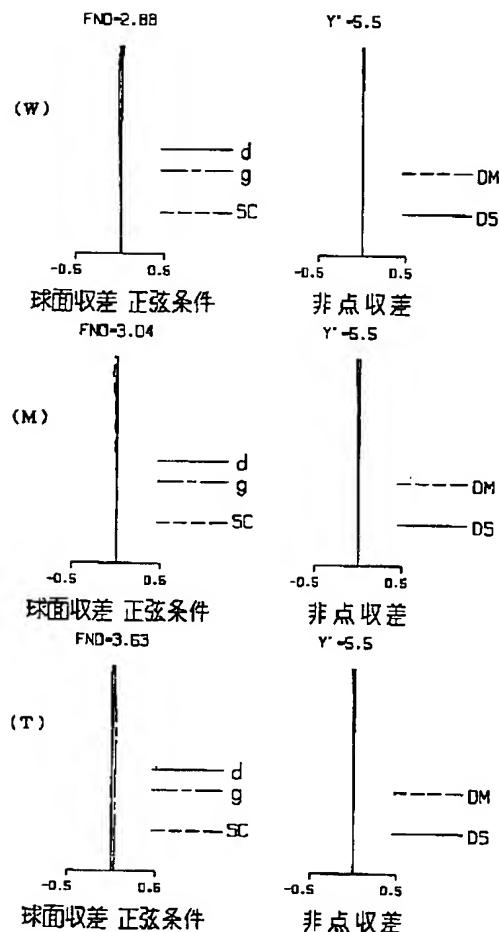
【図11】



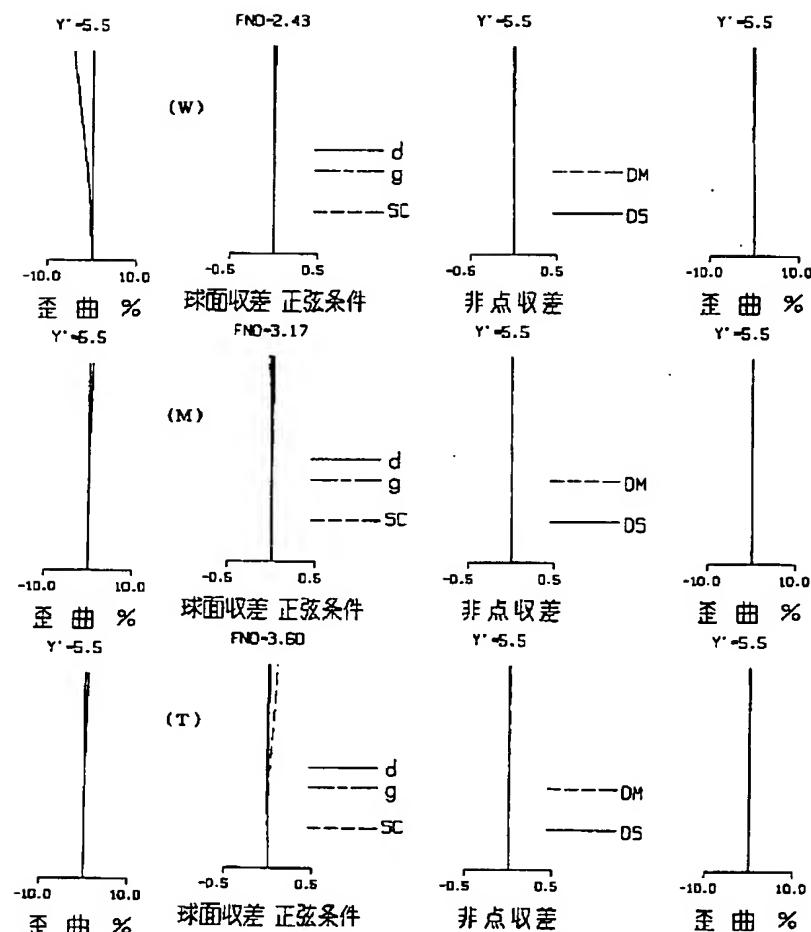
【図12】



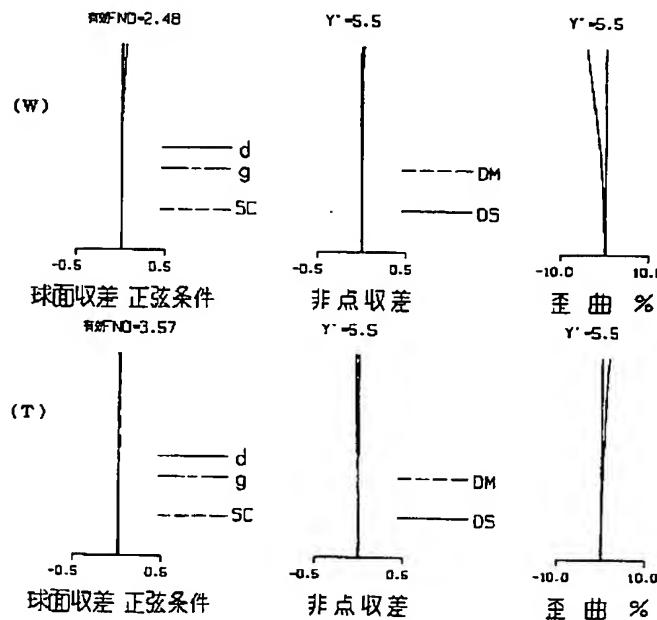
【図13】



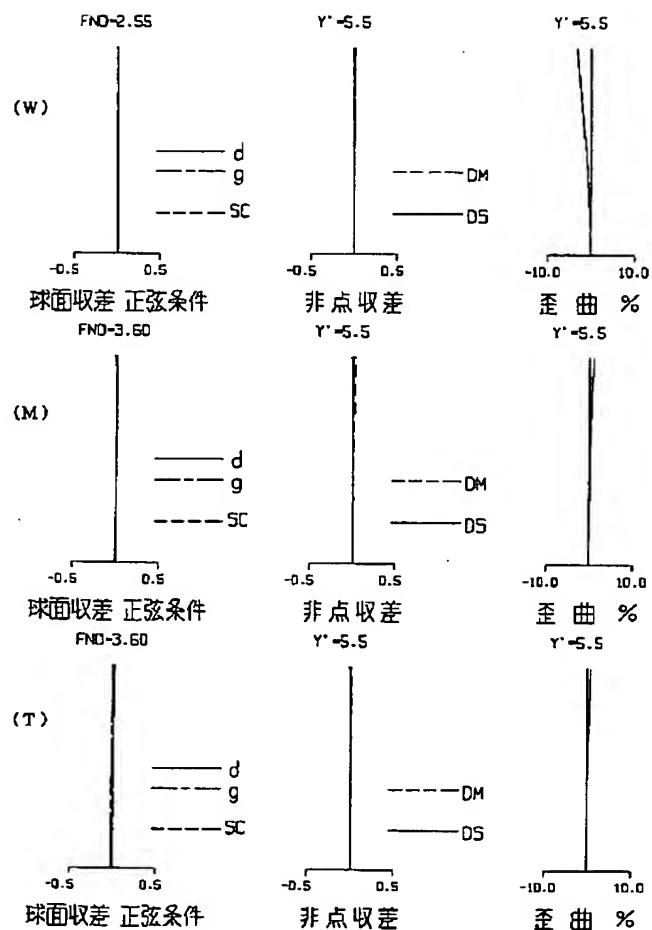
【図14】



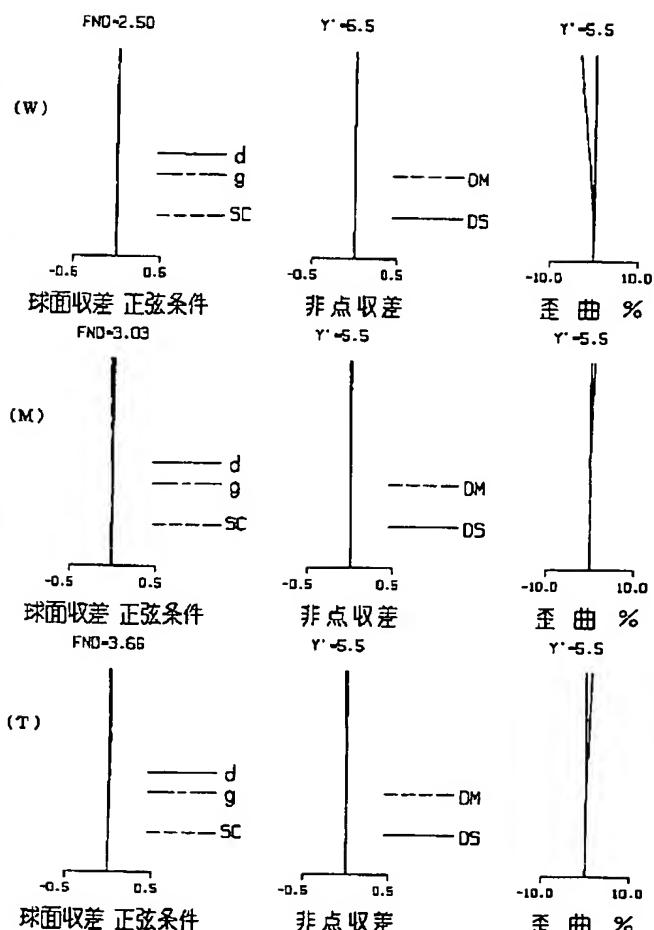
【図20】



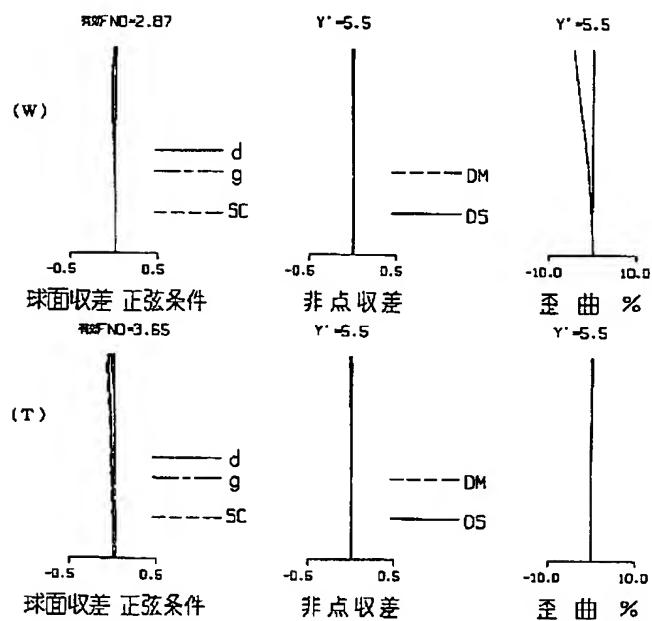
【図15】



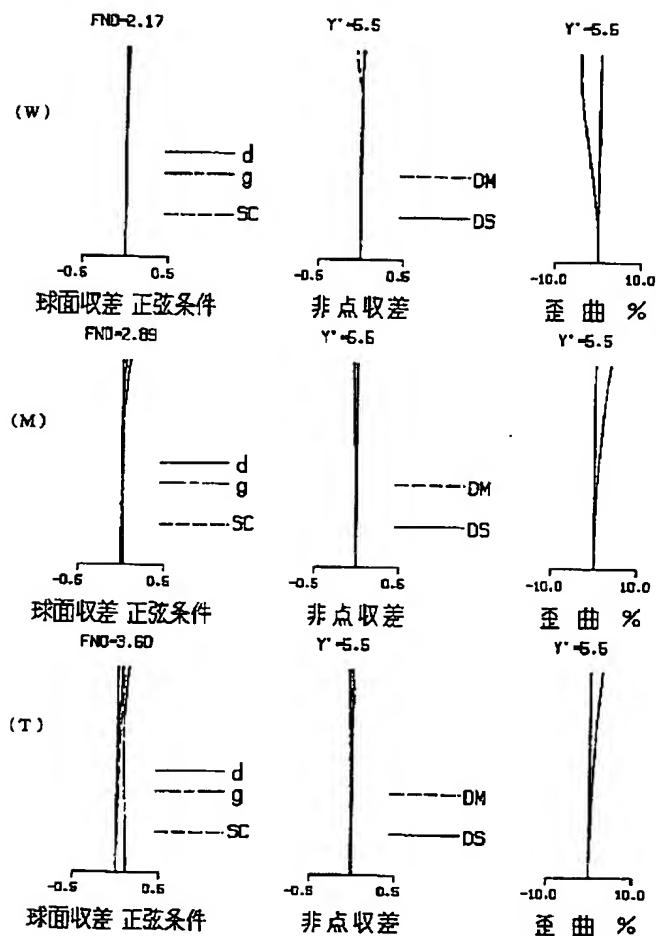
【図16】



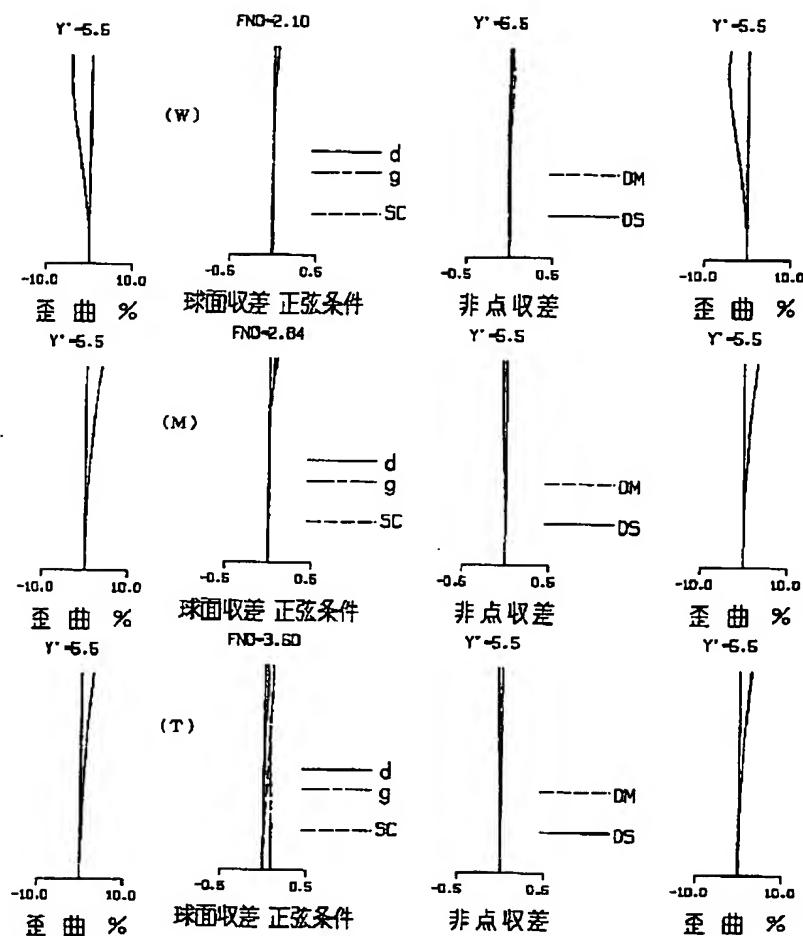
【図22】



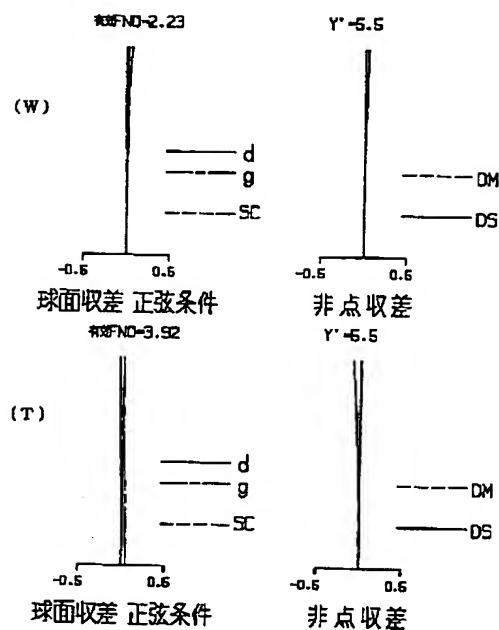
【図17】



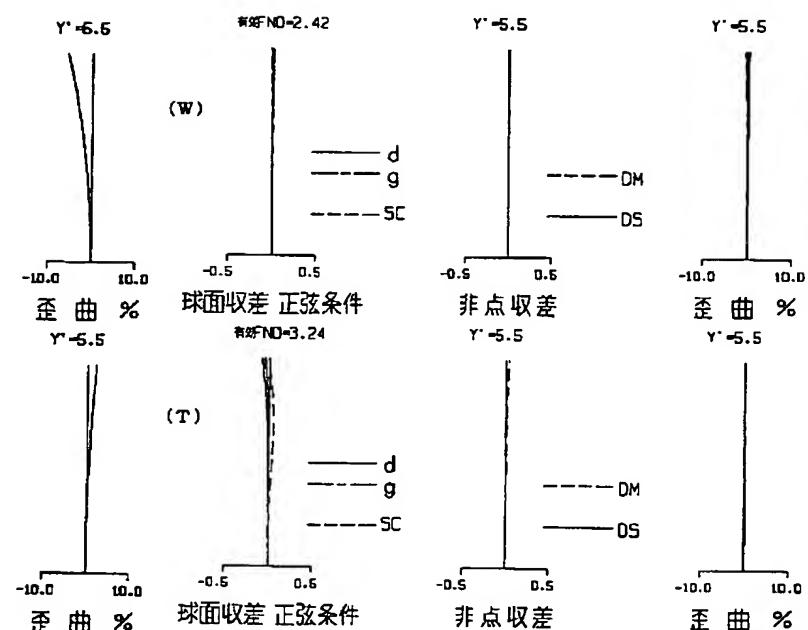
【図18】



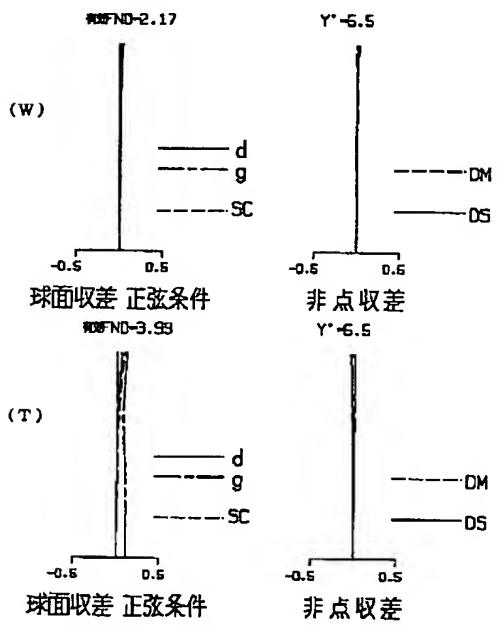
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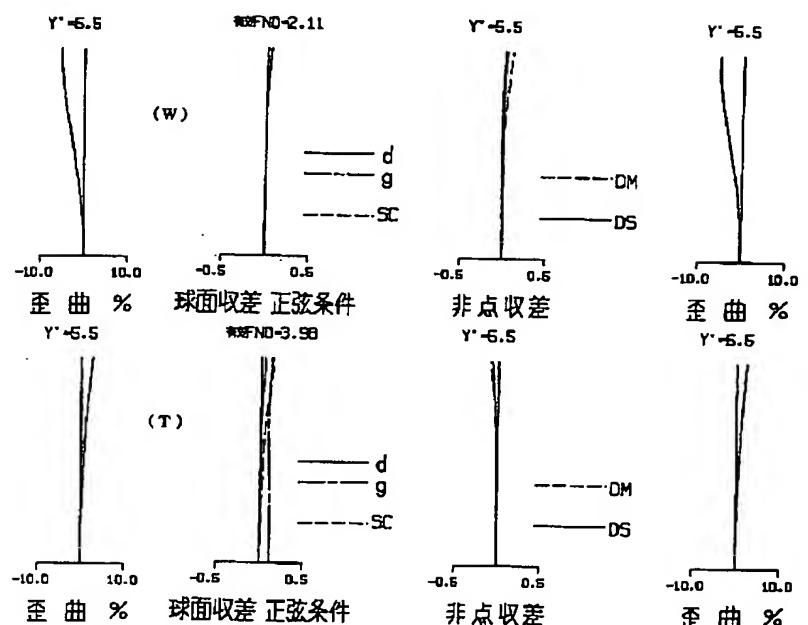
【図23】



【図24】



【図25】



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(72)発明者 磯野 雅史

大阪市中央区安土町二丁目3番13号 大阪  
国際ビル ミノルタ株式会社内

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